2016

Examining the Relative Age Effect and Influence of Academic Timing on Participation in Canadian Interuniversity Sport

Laura Chittle
University of Windsor

Examining the Relative Age Effect and Influence of Academic Timing on Participation in Canadian Interuniversity Sport

By

Laura Chittle

A Thesis
Submitted to the Faculty of Graduate Studies
through the Department of Kinesiology
in Partial Fulfillment of the Requirements for
the Degree of Master of Human Kinetics
at the University of Windsor

Windsor, Ontario, Canada

2016

Examining the Relative Age Effect and Influence of Academic Timing on Participation in Canadian Interuniversity Sport

by

Laura Chittle

APPROVED BY:

Dr. M. El-Masri
Faculty of Nursing

Dr. P. Weir
Department of Kinesiology

Dr. S. Horton, Co-Advisor
Department of Kinesiology

Dr. J. Dixon, Co-Advisor
Department of Kinesiology

June 10, 2016

DECLARATION OF PREVIOUS PUBLICATION

This thesis includes data that served as the basis for one original paper that has been published in a peer-reviewed journal, as follows:

Publication title/full citation	Publication status
Exploring the Relative Age Effect in Canadian Interuniversity Ice Hockey	*Talent Development & Excellence*

I certify that the above material describes work completed during my registration as graduate student at the University of Windsor.

I declare that, to the best of my knowledge, my thesis does not infringe upon anyone's copyright nor violate any proprietary rights and that any ideas, techniques, quotations, or any other material from the work of other people included in my thesis, published or otherwise, are fully acknowledged in accordance with the standard referencing practices. Furthermore, to the extent that I have included copyrighted material that surpasses the bounds of fair dealing within the meaning of the Canada Copyright Act, I certify that I have obtained a written permission from the copyright owner(s) to include such material(s) in my thesis (see Appendix: Copyright Permission).

I declare that this is a true copy of my thesis, including any final revisions, as approved by my thesis committee and the Graduate Studies office, and that this thesis has not been submitted for a higher degree to any other University or Institution.

ABSTRACT

Relative age effects (RAE) are developmental advantages experienced by those born in the initial months after a predetermined cut-off date over their younger counterparts. Student-athletes are considered to be ‘on-time’ when their current year of athletic eligibility coincides with their expected year of athletic eligibility, based on their year of birth. Conversely, student-athletes are considered ‘delayed’ when their current athletic eligibility year corresponds with a younger cohort. This project examined the RAE and academic timing within nine of the 12 Canadian Interuniversity Sport (CIS) championship sports. A moderate RAE was seen among the entire sample of CIS student-athletes. Males are more likely to be delayed than females, and those student-athletes born in the later months of the year are more frequently delayed compared to their relatively older peers. Based on these results, delaying one’s athletic eligibly may be an effective method to reduce the disadvantages associated with being relatively younger.

DEDICATION

Mom and Dad,

For providing me with every opportunity and teaching me that hard work is the essence of all success.

ACKNOWLEDGEMENTS

The creation of this document would not have been possible without the involvement of a number of people. These pages serve to recognize these individuals and the significant roles they have played in making my graduate experience one that I will cherish for a lifetime.

Dr. Jess Dixon- for your guidance, continuous support, and long-term commitment to my success. Words cannot express how thankful I am to have had you as an advisor and friend. Your work ethic is inspiring and the learning environment that you create is unlike any other, thank you for always having your door open. I am a better researcher and person because of the time you have given me. I appreciate every pep talk, challenge, and opportunity you have provided.

Dr. Sean Horton- for your immense knowledge, patience, and confidence in me. You have fostered my curiosity and independence, which will undoubtedly serve me well as I move forward. I am grateful for your friendship, advisement, and the significant role you have had in making graduate school such an enjoyable experience.

Dr. Patti Weir- for your encouragement, suggestions, and valuable insight on this topic. My document is stronger because of your involvement.

Dr. Maher El-Masri- for your willingness to be a member of my committee, meeting with me on numerous occasions, and sharing your statistical expertise, I am forever grateful.

Dr. Wayne Marino- for chairing my thesis defence and your support throughout my undergraduate and graduate degrees.

Canadian Interuniversity Sport- for your continual support of this project and helping to facilitate it.

Social Sciences and Humanities Research Council & Ontario Graduate Scholarship- for funding this research project.

Mom, Dad, Diane, & Mark- for years of love and encouragement.

Grace, Ava, & Ellie- for being the sweetest nieces, providing me with countless hugs and much needed play breaks.

Aaron- for keeping me sane, laughing with me through the challenging times, and unwavering support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

RESEARCH ARTICLE

Introduction

Researchers within sport and education domains have demonstrated that the practice of grouping individuals based on chronological age into cohorts advantages some and disadvantages others (Baker, Schorer, & Cobley, 2010; Musch & Grondin, 2001; Vincent & Glamser, 2006). This phenomenon is known as the relative age effect (RAE) and describes the developmental advantages experienced by those born early in the year relative to a specific cut-off date over those born later in the year. These advantages stem from relative age differences that can be explained as the disparity in ages among the individuals grouped according to the prescribed selection date (Barnsley & Thompson, 1988; Barnsley, Thompson, & Barnsley, 1985). To help illustrate this, consider that at 10 years old, the 11 month age difference between individuals born in January and December represents nearly 10% of their total life experience (Musch & Grondin, 2001). While these age differences may seem insignificant, they can lead relatively older children to experience accumulated advantages over time, resulting in an increased likelihood of being selected for high caliber teams that are consequently associated with better coaching, more practice and/or playing time, and enhanced competition (Barnsley & Thompson, 1988; Barnsley et al., 1985; Musch & Grondin, 2001). On the contrary, those who are relatively younger may be overlooked for such experiences and, as a result, drop out of sport (Helsen, Starkes, & Van Winckel, 1998).

Evidence of the RAE was first noted in education when differences in attainment outcomes were seen as a result of relative age (Armstrong, 1966; Freyman, 1965). Since these studies, numerous researchers have found relative age to influence students in terms of grade attainment (e.g., Bedard & Dhuey, 2006; Cobley, Baker, Wattie, & McKenna, 2009a; Smith, 2009), as well as athletes in a wide variety of sports (e.g., Cobley, Baker, Wattie, & McKenna, 2009b; Musch & Grondin, 2001). While the RAE has become a prevalent focus among academics, this phenomenon invaded popular culture when Malcolm Gladwell (2008) featured the topic in the opening chapter of his best-selling book *Outliers: The Story of Success*. Relative age effects have also been featured as a headline story on the news program *60 Minutes* (CBS Interactive, 2012).

While most RAE research has focused on professional and youth sport (e.g., Cobley et al., 2009b), few investigations have explored its prevalence at the intercollegiate/interuniversity level. To date, there have been only a few studies (e.g., Chittle, Horton, & Dixon, 2016; Dixon, Liburdi, Horton, & Weir, 2013; Glamser & Marciani, 1992; Grondin, Deschaies, & Nault, 1984; Montelpare, Scott, & Pelino, 2000) that have examined the RAE in an intercollegiate/interuniversity setting. Canadian Interuniversity Sport (CIS) is the primary governing body for interuniversity athletics in Canadian universities that encompasses 12 different sports, 55 member institutions, four regional conferences[1], and more than 11,000 student-athletes (Canadian Interuniversity Sport, n.d.). There continues to be conflicting findings regarding the presence of RAEs within intercollegiate sport. Specifically, researchers have demonstrated RAEs among Canadian Interuniversity Athletic Union (CIAU; predecessor of CIS) ice hockey players (Montelpare et al., 2000) and National Collegiate Athletic Association (NCAA) Division

[1]These four regional conferences include: Canada West Universities Athletic Association (CWUAA), Ontario University Athletics (OUA), Réseau du sport étudiant du Québec (RSEQ), and Atlantic University Sport (AUS).

I female softball players (Dixon et al., 2013). However, others have found RAEs to be absent in overall samples of Canadian university ice hockey players (Grondin et al., 1984), two NCAA Division I football teams (Glamser & Marciani, 1992), and NCAA Division I basketball players (Chittle et al., 2016). Moreover, only some of these studies have taken into account the influence of academic timing (AT; Glamser & Marciani, 1992), with the vast majority of them emanating from one research group. Therefore, the purpose of this thesis is to examine the RAE within all 12 CIS championship sports while accounting for the impact of academic timing.

Literature Review

The RAE is a multifaceted phenomenon with numerous contributing factors and antecedents. For example, Musch and Grondin (2001) highlighted competition, physical development, psychological factors, and experience as mechanisms that contribute to the formation of the RAE. Moreover, Dixon, Horton, and Weir (2011) proposed a simplified model whereby RAEs tend to exist in systems where individuals are selected based on their ability, and then placed into various streams (e.g., gifted, representative) that offer different opportunities for play, practice time, and instructional support (see Figure 1). Given that streaming is common within sport and education environments, it is not surprising that RAEs are often found in these settings.

More recently, Wattie, Schorer, and Baker (2015) created a theoretical model to account for the broad range of mechanisms that may influence the presence or absence of RAEs. Wattie et al. (2015) highlighted three interacting constraints that can impact RAE profiles in various situations: individual constraints (e.g., birth date, sex, physical maturation and size, handedness), task constraints (e.g., physicality of sport, laterality advantage, participation level, playing position), and environmental constraints (e.g., age and other grouping policies, family influence, popularity of sport, coach influence). This developmental model is effective in displaying how different circumstances can result in unique constraint profiles, and how the contribution of each constraint type may differ depending on the situation or system (See Figures 2a, 2b, and 2c). Within the current study, while physical and psychological maturational differences may be minimal, competition is still evident, as are differing sporting experiences among CIS student-athletes. As a result, it is likely that an early selection advantage, with its benefits accruing over time, leads to an accumulated advantage for relatively older athletes, thereby impacting who is afforded the opportunity to participate in CIS sports.

RAEs in Sport

Cobley et al.'s (2009b) meta-analysis presented a comprehensive state of the RAE in sport with the vast majority of research to that point being focused on ice hockey (32.8%), soccer (30%), and baseball (13%). Since this review, RAE research has expanded considerably to include many more sports and competitive levels. Specifically, ice hockey and soccer have consistently demonstrated RAEs, perhaps due to their cultural popularity in Canada and Europe, respectively, which may enhance the likelihood of finding an effect (Baker et al., 2010; Dixon et al., 2011; Musch & Grondin, 2001). For example, each of these sports have displayed RAEs at the professional level (*ice hockey:* e.g., Addona & Yates, 2010; Nolan & Howell, 2010; *soccer:* e.g., Cobley, Schorer, & Baker, 2008; Helsen et al., 1998) and among youth athletes (*ice hockey:* e.g., Barnsley &

Thompson, 1988; Hancock, Ste-Marie, &Young, 2013; *soccer:* e.g., Delorme, Boiché, & Raspaud, 2010; Vincent & Glamser, 2006).

Studies conducted on football (e.g., MacDonald, Cheung, Côté, & Abernethy, 2009; Daniel & Janssen, 1987) and volleyball (e.g., Delorme, Boiché, & Raspaud, 2009; Lidor, Arnon, Maaya, Gershon, & Côté, 2014) tend to display no systematic birthdate advantages for relatively older players. Conversely, despite some differences between studies, generally, an unequal birthdate distribution supporting the RAE pattern has been noted in professional rugby leagues (Cobley, Hanratty, O'Connor, & Cotton, 2014; Till et al., 2010), as well as among youth rugby players (Cobley, Abraham, Baker, 2008; Roberts & Fairclough, 2012; Wilson, 1999).

The sport of basketball shows inconsistent findings with respect to the state of RAEs. Researchers have typically failed to find RAEs in the National Basketball Association across a number of seasons (e.g., Côté, MacDonald, Baker, & Abernethy, 2006; Daniel & Janssen, 1987; Esteva & Drobnic, 2006), yet others have found it in professional leagues in Japan (Nakata & Sakkamoto, 2011) and Germany (Schorer, Neumann, Cobley, Tietjens, & Baker, 2011), as well as in elite youth levels of the sport (Delorme & Raspaud, 2009; García, Aguilar, Romero, Lastra, & Oliveira, 2014). While there are only a few cited studies, generally RAEs have also been noted in curling (Raschner, Müller, & Hildebrandt, 2012), field hockey (Wilson, 1999), swimming (e.g., Baxter-Jones & Helms, 1994; Baxter-Jones, Helms, Baines-Preece, & Preece, 1994; Costa, Marques, Louro, Ferreira, & Marinho, 2013), and track and field (Nakata & Sakamoto, 2011; Romann & Cobley, 2015).

RAEs in Intercollegiate/Interuniversity Sport

Although RAE research has included studies on most of the 12 CIS championships sports (cross country and wrestling notwithstanding), the large majority of these have taken place at the youth and/or professional level. As a result, there continues to be a dearth in the literature on the state of RAEs among intercollegiate/interuniversity student-athletes. Grondin et al. (1984) presented the first investigation on RAEs among Canadian university ice hockey players, finding no RAE to be present within this sample. Instead, these authors noted a slight underrepresentation of athletes born in quartiles three and four but this did not reach statistical significance. Years later, Montelpare et al. (2000) displayed conflicting results among CIAU ice hockey players, indicating that more than 69% of the players were born in the first half of the year.

Of the existing research dedicated to intercollegiate/interuniversity sport, the bulk of it has focused on American athletes participating in the NCAA (e.g., Chittle et al., 2016, Dixon et al., 2013; Glamser & Marciani, 1992). Glamser and Marciani (1992) analyzed the birthdates of two NCAA Division I football and baseball teams, finding a nearly equal birthdate distribution in both instances. These authors were the first to highlight the importance of academic timing (AT) when analyzing student-athletes in an intercollegiate setting, after acknowledging that athletes participating in intercollegiate sports often differ in ages because they are grouped based on grade level, rather than their absolute age. The term AT explains how differences in a student-athlete’s actual and expected athletic eligibilities may influence his or her participation and/or success in interuniversity and/or intercollegiate sport (Dixon et al., 2013).

For example, student-athletes born in 1998 who begin kindergarten at five years of age ought to begin their first year of university and be in their first year of athletic eligibility in the fall of 2016, assuming they did not fail or skip one or more grades prior to commencing university. Correspondingly, those born in 1997, 1996, 1995, and 1994 would be in their second, third, fourth, and fifth years of eligibility, respectively. When examining AT, student-athletes are considered to be ‘on-time’ when their current year of athletic eligibility coincides with their expected year of athletic eligibility, based on their year of birth. Conversely, student-athletes are considered to be ‘delayed’ when their current athletic eligibility year corresponds with a younger cohort of student-athletes. Once again, student-athletes born in 1998 in their first year of athletic eligibility in the fall of 2016 would be classified as on-time. Alternatively, student-athletes born in 1997 and in their first year of athletic eligibility in the fall of 2016 would be considered delayed because they should in fact be in their second year of athletic eligibility. Although there is the possibility for student-athletes to be ‘advanced’ in terms of their eligibility status, these instances are comparatively rare. This refers to when a student-athlete’s current year of athletic eligibility is earlier than what would have been projected based on his or her year of birth.

Once Glamser and Marciani (1992) isolated their analyses to student-athletes who were on-time, they noticed that football players were five times more likely to be born in quartile one than quartile four. Moreover, they noted that 45% of the football players were delayed by at least one year. With respect to the baseball data, the birthdate distribution of players did not indicate a relative age advantage. However, when considering AT, as many as 37% of these players were found to be delayed. Subsequent research by Dixon et al. (2013) witnessed similar trends regarding AT among NCAA Division I female softball players. When considering their overall sample of student-athletes, they noted a significant over-representation of student-athletes born in quartile one (28%) and a significant under-representation of athletes born in quartile three (22%). After taking into consideration the notion of AT, they revealed a stronger RAE among on-time student-athletes, with 36% of these athletes born in quartile one and 8% born in quartile four. In contrast, when looking at those who were delayed, they found a significant reversal in the traditional RAE, whereby 12% of these athletes were born in quartile one and 54% born in quartile four.

Most recently, Chittle et al. (2016) evaluated NCAA Division I men's and women's basketball players and found similar results to Glamser and Marciani (1992) and Dixon et al. (2013). When examining their overall samples of student-athletes, they found no RAE for female or male basketball players. However, after isolating for those players who were on-time, they found a significant traditional RAE, with male and female athletes approximately 30 and slightly over five times more likely to be born in quartile one than quartile four, respectively. Conversely, delayed males and females were nearly twice and almost five times more likely to be born in quartile 4 and quartile one, respectively.

Academic timing is an important environmental constraint that is associated with RAEs in educational systems, specifically intercollegiate/interuniversity sport. Wattie et al. (2015) highlighted that "…environmental constraints refer to the broader social constructs that affect development, including physical environment, socio-cultural environment, policies, and the influence of important actors in athletes' lives, such as coaches, family and friends" (p. 84). It is the structure of intercollegiate/interuniversity sport that allows student-athletes to differ so considerably in age. This is due, in part, to policies and regulations (or lack thereof) that allow students to delay their athletic eligibilities and/or postpone their entries into university for various reasons. Consequently, it is this unique environment that affords student-athletes the opportunity to be on-time, delayed, and/or advanced.

While there are many reasons for student-athletes to be delayed in their athletic eligibilities, it is difficult to determine precisely why without detailed accounts of their lives and/or educational histories. A common cause of delay is 'redshirting,' which allows student-athletes to be members of varsity teams but not compete in league play and, therefore, not use up a year of athletic eligibility. Other causes of delay may include failing or repeating one or more grades, or commencing kindergarten late (Deming & Dynarski, 2008). Alternatively, some student-athletes may be delayed after taking a voluntary fifth year of high school, which is often referred to as a 'victory lap.' Students will sometimes choose this route in order to continue their participation in extracurricular activities (including sports), improve their academics, or because of a perceived lack of maturity to attend university (Brady & Allingham, 2010).

Overall, AT is an important factor that can influence the RAE in interuniversity and/or intercollegiate sports. Based on the results of these previous studies (e.g., Chittle et al., 2016; Dixon et al., 2013; Glamser & Marciani, 1992), it appears that delaying one's athletic eligibility by one or more years may be a method to help equalize playing opportunities for relatively younger student-athletes. This is a possibility because Glamser and Marciani (1992) and Chittle et al. (2016) witnessed no RAEs in their entire samples of student-athletes, indicating those who are relatively younger are not disadvantaged, so long as they delay their eligibilities by one or more years. Based on these prior studies, it appears that delaying through red-shirting and/other methods may be a solution to the RAE within intercollegiate settings and potentially beyond this particular environment. The NCAA has, perhaps unwittingly, effectively neutralized the (dis)advantage associated with relative age in certain sports (Chittle et al., 2016). Alternatively, it is important to acknowledge the repercussions that delaying has, including late entry into the workforce which can result in lost wages (Eide & Goldhaber, 2005). Furthermore, in circumstances where parents delay their children from commencing kindergarten, this act is a luxury that only affluent families, who can afford an additional year of child care, can benefit from (Chittle et al., 2016).

Noticeably lacking from the extant literature is information pertaining to the overall state of the RAE among CIS student-athletes. Of the few RAE studies that have examined Canadian interuniversity athletes, none have taken into consideration AT to determine the extent to which the RAE is present. Overall, the ability to isolate for academic timing (i.e., analyzing those who are on-time and delayed separately) provides a new level of complexity and permits the elucidation of subtleties that would typically be overlooked in a typical RAE analysis (Chittle et al., 2016). As a result, the goals of this research study are to: 1) identify if there is a RAE among the entire sample of CIS student-athletes collapsed across sports, as well as in each CIS championship sport; 2) determine if RAEs are present among the on-time, delayed, and advanced CIS students-athletes in their entirety and within each championship sport[2], and; 3) discover if quartile of birth and sex can predict the academic timing status (i.e., whether a student-athlete is on-time or delayed) of CIS student-athletes.

Design and Methods

Target Population

The target population for this study was student-athletes who competed in one of the 12 championship sports sanctioned by CIS during the 2013-2014 season (i.e., basketball, cross county, curling, field hockey, football, ice hockey, rugby, soccer, swimming, track and field, volleyball, and wrestling). These student-athletes attended one of the 55 CIS-member universities across Canada during this same academic year. The birthdates and eligibility years of all student-athletes were gathered from eligibility certificates obtained from the CIS office. Rosters were reviewed on the World Wide Web in an attempt to find birthdate information when universities failed to provide it within their eligibility certificates. In most instances, birthdate information was not listed in the World Wide Web and, therefore, these the student-athletes were removed from the analyses. These data were further delimited to include only those student-athletes who were born in Canada, as other countries may use different sport cut-off dates and have different sport developmental systems. This decision is further justified on the basis that the results of this study will be generalized to Canadian-born student-athletes, and that the birth distribution of the general population in different countries may vary due to

[2] There will be no analysis conducted on the advanced student-athletes within each championship sport since there will be too few of these athletes to ensure adequate power.

various cultural, biological, and other phenomena (Buckles & Hungerman, 2013; Cowgill, 1966). In total, 699 student-athletes were removed from the analysis (5.76%) as a result of being born outside of Canada.

Categorization of Student-athletes

Student-athletes were initially categorized by sex and sport. Following this step, student-athletes were placed into the appropriate birth quartile relative to their respective sport's annual cut-off date, as determined by each sport's governing body within Canada. In cases where this information was not publically available on the World Wide Web, representatives from each organization were emailed to confirm the sport's annual cut-off date. Through this process, it was determined that the sport governing bodies for swimming and wrestling do not rely on yearly cut-off dates to group athletes. Furthermore, there has not been a consistent cut-off date for curling in recent years, making it difficult to determine the relative ages of student-athletes participating in this sport. Consequently, the student-athletes participating in curling, swimming, and wrestling were removed from the analysis.

The cut-off dates for each sport within the study population can be found in Table 1. Since all of the sports within the study population utilized a December 31st cut-off date (or January 1st in the case of Basketball Canada), quartile one (Q1) contains the months of January, February, and March, quartile two (Q2) represents April, May, and June, quartile three (Q3) is comprised of July, August, and September, and quartile four (Q4) includes October, November, and December. The remaining student-athletes were also identified as on-time or delayed based on their year of birth and current athletic eligibility. For the 2013-2014 CIS season, on-time student-athletes born in 1995, 1994, 1993, 1992, and 1991 ought to be in their first through fifth years of athletic eligibility, respectively. Students whose athletic eligibilities corresponded with a later birth year were considered delayed, while those whose eligibilities corresponded with an earlier birth year were considered advanced.

Student-athletes who attended a Collège d'enseignement général et professionnel (CEGEP) high school in Quebec began university one year later than projected. This was accounted for when classifying student-athletes as being on-time, delayed, or advanced by adjusting their athletic eligibilities to account for these initial age differences. Specifically, for student-athletes born in Quebec who attended a university that competes in one of CWUAA, OUA, AUS conferences, their athletic eligibilities were modified to account for them being one year older when they commenced university. In cases where student-athletes were born outside of Quebec but competed in the RSEQ, their athletic eligibilities were adjusted to account for them being one year younger when they began university. Finally, for those who were born in Quebec and competed in the RSEQ, no adjustments were made because the majority of competition to make a team within this conference would have been among fellow Quebec athletes who followed the same schooling system.

Data Analysis

A series of chi-square goodness of fit tests (X^2) were performed using SPSS 22.0, and the results were evaluated at $p < .05$:

a) For each sex (i.e., male and female), a chi-square goodness of fit test was performed on the entire sample of CIS student-athletes (collapsed across sport). Supplementary chi-square analyses were performed on both sexes for student-athletes identified as on-time, delayed, and advanced to reveal the overall effects of AT in CIS.

b) For each sport within the study population (i.e., basketball, cross county, field hockey, football, ice hockey, rugby, soccer, track and field, and volleyball), a chi-square goodness of fit test was conducted on the overall male and female samples of student-athletes, as well as for those who were on-time, and delayed. Please note that because only a small number of CIS student-athletes were advanced (2.47%), there was not a large enough sample to perform a chi-square test on these groups in each sport.

These chi-square analyses allowed for univariate comparisons to be made between the frequency of student-athletes' birthdates and the expected distribution across each birth quartile. For the expected birthdate distribution, population birth rates from the Human Fertility Database in Canada (2013) for the years of 1989 through 1995 were utilized (summating monthly birth rates to create quartiles), with the years chosen reflecting 96.9% of the birth years for the student-athletes during the 2013-14 academic year. This approach has been employed in a number of previous RAE studies (e.g., Barnsley et al., 1985; Cobley et al., 2014; Dixon et al., 2013; Nolan & Howell, 2010). Delorme and Champely (2015) also suggest that when conducting chi-square analyses for RAE studies, the theoretical expected distribution should be based on the 'parent' population in order to reduce the likelihood of making a Type I error. Since the birthdate distribution for all students attending a Canadian university is not readily available, population birth rates were the next most accurate expected distribution.

In order to determine the practical significance of the results from the chi-square analyses, effect sizes were calculated using Cramér's phi (φ), where 0.1, 0.3, and 0.5 indicate small, medium, and large effect sizes, respectively (Cohen, 1992). Following a significant chi-square result, standardized residuals were calculated to determine which birth quartiles differed significantly from what would be expected based on Canadian population birth rates. At the $p < .05$ significance level, standardized residuals greater than 1.96 indicate an over-representation of births, while standardized residuals less than -1.96 indicate an under-representation of births.

Subsequent to these univariate analyses, a binary logistic regression analysis was performed on the study population of CIS student-athletes in order to generate a model that can predict the academic timing status of student-athletes (i.e., on-time or delayed) based on their sex (i.e., male or female) and quartile of birth (i.e., Q1, Q2, Q3, and Q4). For this analysis, male, and Q4 served as the reference categories for sex and birth quartile, respectively. Sport was not included as a variable in the overall model as it led to a poor model fit. Therefore, subgroup binary logistic regression analyses were conducted on each of the nine CIS sports in order to predict academic timing status based on sex and quartile of birth. Using the subgroup models also prevented the need for a large number of dummy-coded sport variables in the overall model, which would have led to difficulties drawing meaningful conclusions across each sport with the reference category. These multivariate tests complement the chi-square tests by providing a more robust analysis that will yield statistically and practically meaningful information about the variables included in the model (e.g., odds ratios, confidence intervals). Once again, it is important to note that advanced student-athletes were removed from all of the regression analyses because they represent a very small portion of the study population (2.47%). Since binary logistic regression uses a goodness-of-fit test to assess the fit of the model to the data, if any of the cells have expected frequencies that are too small (usually fewer than five cases), the analysis may have little power (Tabachnick & Fidell, 1996). Including advanced student-athletes would result in there being empty cells, and other cells with small expected frequencies.

Finally, for these analyses, multicollinearity was assessed for each independent variable using standard error coefficients, whereby a standard error value of less than two (< 2) indicates no multicollinearity. Multivariate outliers were examined using the Mahalanobis distance and Cook's distance points (Stevens, 2009). Mahalanobis distance measures the distance of a case from the centroid of all cases for the predictor variables (Stevens, 2009). The Mahalanobis distance points were compared with a critical value of the X^2 distribution (i.e., chi-square distribution) evaluated at $p < .001$, with the number of predictors (i.e., independent variables) used as the degrees of freedom. In cases where an outlier point (as determined from the Mahalanobis distance) had a Cook's distance of greater than one (>1), the outlier was considered an influential data point and was deleted from the supplementary analysis (Stevens, 2009). Sensitivity and specificity values were calculated for the overall and subgroup models. Sensitivity refers to the proportion of student-athletes that are actually on-time and that the model correctly identified as being on-time. Alternatively, specificity is the proportion of student-athletes that are actually delayed and that the model correctly identified as such. Finally, these logistic regressions were conducted using the standard (enter) method.

When data are collapsed and not analyzed on a sport-to-sport basis some student-athletes may be included in the analysis more than once because they competed in more than one CIS sport during the 2013-2014 season. However, because only 3.16% of athletes competed in multiple sports (with no athletes competing in more than two sports), dependent observations and data clustering are not considered problematic.

Results

Descriptive Statistics

For this investigation, male (n = 4754; M_{age}= 21.07) and female (n = 4170; M_{age}= 20.10) CIS student-athletes were targeted and included in the analysis. Of the entire sample of CIS student-athletes (collapsed across sport), 25.33% of males were deemed on-time, 73.33% delayed, and 1.35% advanced. Alternatively, for the female student-athletes sample, 56.76% were classified as on-time, 39.50% delayed, and 3.74% advanced. Ice hockey had the largest percentage of delayed male student-athletes (99.76%), with the vast majority of these players delayed by three years (71.93%), while volleyball had the greatest percentage of on-time male athletes (56.67%). Among females, cross country comprised the highest percentage of delayed student-athletes (64.38%), with most of these individuals delayed by one year (42.64%), while volleyball once again had the most on-time female student-athletes (68.89%). For the male student-athletes, the number of years student-athletes were delayed ranged from 1 to 18 years, with track and field having two athletes delayed by 18 years. Comparatively, delayed female athletes ranged from 1 to 22 years delayed, with cross country having one athlete delayed by 22 years. For a detailed summary of descriptive statistics regarding athletes who are on-time, delayed, and advanced see Table 2. A visual representation of the proportion of student-athletes who are on-time, delayed, and advanced for each sport can be seen in Figures 3-17.

Chi-Square Analyses

The results of the overall chi-square goodness of fit test revealed a significant RAE across birth quartiles for both the male and female student-athletes (males: X^2 = 67.84, $df = 3$, $p < 0.001$, $\varphi = 0.12$; females: $X^2 = 40.87$, $df = 3$, $p < 0.001$, $\varphi = 0.10$). The standardized residual scores indicated significant differences for all the birth quartiles, except Q2 in the male sample (see Figure 3). In order to reveal the moderating effects that AT has on the RAE, supplementary analyses were performed on those student-athletes who were on-time, delayed, and advanced. For those considered on-time, strong evidence of a RAE was seen among the male ($X^2 = 61.54$, $df = 3$, $p < 0.001$, $\varphi = 0.23$) and female ($X^2 = 72.96$, $df = 3$, $p < 0.001$, $\varphi = 0.18$) student-athletes, favouring athletes born in the early months of the year compared to the latter (see Figure 4). Significant chi-square values were also noted for the delayed male and female student-athletes (male: X^2 = 22.53, $df = 3$, $p < 0.001$, $\varphi = 0.08$; female: $X^2 = 11.75$, $df = 3$, $p = 0.008$, $\varphi = 0.08$). Despite these significant chi-square values, only 53.81% and 50.58% of the male and female delayed samples were born in the first half of the year compared to the second, respectively (see Figure 5). Finally, a traditional significant RAE was found among the male and female advanced student-athletes (male: $X^2 = 9.93$, $df = 3$, $p = 0.019$, $\varphi = 0.39$; female: $X^2 = 24.14$, $df = 3$, $p < 0.001$, $\varphi = 0.39$) (see Figure 6).

Among the overall samples of student-athletes in each individual sport (i.e., athletes combined regardless of AT), significant chi-square results were found among male basketball players ($X^2 = 8.47$, $df = 3$, $p = 0.037$ $\varphi = 0.14$), female cross country athletes ($X^2 = 7.84$, $df = 3$, $p = 0.050$, $\varphi = 0.16$), male and female ice hockey players (male: $X^2 = 79.25$, $df = 3$, $p < 0.001$, $\varphi = 0.31$; female: $X^2 = 23.89$, $df = 3$, $p < 0.001$, $\varphi = 0.19$), male and female soccer players (male: $X^2 = 27.58$, $df = 3$, $p < 0.001$, $\varphi = 0.18$; female: $X^2 = 20.66$, $df = 3$, $p < 0.001$, $\varphi = 0.14$), and male and female volleyball players (male: $X^2 = 16.72$, $df = 3$, $p < 0.001$, $\varphi = 0.23$; female: $X^2 = 11.37$, $df = 3$, $p = 0.010$ $\varphi = 0.16$).

For those classified as on-time, significant RAEs were seen among male basketball players ($X^2 = 10.26$, $df = 3$, $p = 0.016$ $\varphi = 0.29$), male football players ($X^2 = 16.37$, $df = 3$, $p < 0.001$ $\varphi = 0.29$), female ice hockey players ($X^2 = 23.48$, $df = 3$, $p < 0.001$, $\varphi = 0.23$), male and female soccer players (male: $X^2 = 13.49$, $df = 3$, $p = 0.004$, $\varphi = 0.20$; female: $X^2 = 29.83$, $df = 3$, $p < 0.001$, $\varphi = 0.22$), male track and field athletes ($X^2 = 10.89$, $df = 3$, $p = 0.012$ $\varphi = 0.21$), and male and female volleyball players (male: $X^2 = 21.87$, $df = 3$, $p < 0.001$ $\varphi = 0.34$; female: $X^2 = 16.90$, $df = 3$, $p < 0.001$ $\varphi = 0.24$).

Finally, among those considered to be delayed, significant chi-square values were witnessed among male ice hockey players ($X^2 = 79.14$, $df = 3$, $p < 0.001$, $\varphi = 0.31$), male soccer players ($X^2 = 12.76$, $df = 3$, $p = 0.005$, $\varphi = 0.17$), and female track and field athletes ($X^2 = 9.45$, $df = 3$, $p = 0.024$, $\varphi = 0.20$). Despite the significant chi-square results in each of these sports, the pattern of birth distributions varied considerably. Specifically, among the delayed male ice hockey players, a strong traditional RAE was seen, with student-athletes being more than twice as likely to be born in Q1 as Q4. Significant differences in the male ice hockey players were noted in all birth quartiles with the exception of Q2. Similarly, delayed male soccer players exhibited a typical RAE with a gradual reduction in the number of births from Q1 through Q4. However, there was a reversal in the RAE witnessed among the delayed female track and field athletes, with 46.05% of athletes born in the first half of the year and 53.95% in the latter half. Furthermore, there was a significant overrepresentation in the number of athletes born in Q4. For a detailed summary of the statistical results for the analyses related to the birth quartile distribution of CIS student-athletes (as a whole and isolated by sport), please see Table 3.

Binary Logistic Regression Analyses

For this investigation, a binary logistic regression analysis was conducted on the entire sample of CIS student-athletes to predict AT status based on birth quartile and sex. The assumption regarding multicollinearity was met as all standard error coefficients for the independent variables were less than two (< 2). The assumption of multivariate outliers was satisfied as there were no influential data points given that all Cook's distance points were all less than one (< 1). The regression results indicated the model with the variables included (i.e., sex, quartile of birth) was a good fit (Hosmer & Lemeshow = 4.50, $p = 0.609$), and was a significant improvement over the null model $X^2(4) = 1078.85$, $p < 0.001$. Overall, the predictor model explains 11.66%-15.72% of the variance. Sensitivity and specificity values are 55.08% and 76.41%, respectively. Therefore, this model is effective at predicting those student-athletes who are delayed but less effective in its ability to predict on-time student-athletes. Wald statistics indicate that sex and quartile of birth are both significant independent predictors of AT ($p < 0.001$).

For each predictor variable, the 95% confidence intervals are narrow indicating that the odds ratios produced are good estimates of the parameter values. Regression coefficients can be seen in Table 4.

The subgroup binary logistic regression models that included sex and quartile of birth for basketball, ice hockey, soccer, track and field, and volleyball were all significantly better than the null model at predicting AT (basketball: Hosmer & Lemeshow = .589, $p = 0.997$, $X^2(4) = 108.36$, $p < 0.001$, $R^2 = 12.52\%-16.72\%$; ice hockey: Hosmer & Lemeshow = 3.68, $p = 0.719$, $X^2(4) = 992.86$, $p < 0.001$, $R^2 = 49.34\%-69.89\%$; soccer: Hosmer & Lemeshow = 5.01, $p = 0.542$, $X^2(4) = 102.37$, $p < 0.001$, $R^2 = 5.73\%-7.65\%$; track and field: Hosmer & Lemeshow = 1.03, $p = 0.984$, $X^2(4) = 31.10$, $p < 0.001$, $R^2 = 2.82\%-3.77\%$; volleyball: Hosmer & Lemeshow = .30, $p = 0.999$, $X^2(4) = 31.48$, $p < 0.001$, $R^2 = 4.10\%-5.64\%$). Wald statistics indicate that sex and quartile of birth are both significant independent predictors of AT for basketball, soccer, track and field, and volleyball ($p < 0.05$). After controlling for quartile of birth, sex is a predictor of AT in ice hockey ($p < 0.001$); however, quartile of birth is not.

For the subgroup analysis of football, quartile of birth was the only variable included in the model, since females do not compete in this sport. The results indicated that including quartile of birth significantly improved the model compared to the constant only model (football: Hosmer & Lemeshow = < 0.001, $p = 1.000$, $X^2(4) = 20.07$, $p < 0.001$, $R^2 = 1.40\%-2.54\%$). Within football, quartiles one and two were significant predictors of AT. Please see Table 4 for a detailed summary of the statistical results, including the regression coefficients for the binary logistic regression analyses.

Finally, of the subgroup regression models, ice hockey, football, and track and field have specificity values of 81.37%, 100.00%, and 72.99% respectively, indicating these models are particularly effective at predicting delayed athletes. On the contrary, ice hockey and volleyball have extremely high sensitivity values (ice hockey: 99.55%; volleyball: 94.86%), indicating that these models can effectively predict on-time athletes. All sensitivity, specificity, and overall percentage correct values can be seen in Table 5.

Discussion

Chi-Square Summary

A moderate RAE exists within the CIS student-athlete population for the 2013-2014 academic year when athletes are aggregated; however, the effect sizes are small for both the male and female samples. The results indicate a traditional RAE among the male athletes, while the pattern for the female sample is non-linear, exhibiting a peak in the number of athletes born in Q2. Once AT was accounted for, on-time male and female student-athletes were more commonly born in the earlier months of year than the latter, indicating a biased birthdate trend. Although the chi-square test was significant among the delayed male and female student-athletes, the birth date distribution of student-athletes was fairly equal when comparing the first half (male: 53.82%; female: 50.58%) of the calendar year to the second (male: 46.18%; female: 49.42%). Despite the small number of athletes classified as advanced, a strong traditional RAE was seen for both male and female athletes, supporting the notion that those who are relatively older are also more commonly advanced. Specifically, advanced males and females were approximately three times more likely to be born in Q1 than Q4. It is possible that the accumulated advantages experienced by those who are relatively younger (i.e., competition at an elite level, better coaching, more practice time) provided these athletes with a unique skill set that facilitated their advancement with respect to their athletic eligibility. Across the overall, on-time, and delayed female student-athlete samples there was a consistent atypical RAE trend characterized by an overrepresentation in Q2. This overrepresentation in Q2 supports previous findings in the RAE women's literature (e.g., Baker, Schorer, Cobley, Bräutigam, & Büsch, 2009; Delorme et al., 2010; Weir, Smith, Paterson, & Horton, 2010). Regardless of the fairly consistent non-linear trend in female sport, researchers have struggled to explain its occurrence. Vincent and Glamser (2006) suggested that socially constructed gender roles and the stereotyped definition of femininity may lead early maturing females to drop out of sport as a result of being "…less motivated to achieve excellence in competitive sports because of a perception that society does not value female athletic accomplishments in the same way it does those of males" (p. 412). The overrepresentation in Q2 for female sports is a trend that persists into CIS. Despite maturational differences having diminished in importance within interuniversity sport, the RAE still appears in CIS, indicating that the sport experiences children/youth have can continue through the lifespan and influence who is awarded the opportunity to compete at this level.

There has been limited RAE research in many of the CIS championship sports and even fewer projects examining the influence of AT on CIS, making it difficult to draw inferences or make comparisons across studies. While most North American basketball studies do not support the notion of a RAE (e.g., Daniel & Janssen, 1987; Côté et al., 2006), this study displays a slight overrepresentation of male athletes born in the first half (54.96%) of the year compared to the second, with significant differences in Q1. However, the importance of birth quartile is seen once AT is accounted for. For example, on-time male student-athletes were nearly three times more likely to be born in Q1 than Q4, supporting prior notions that on-time student-athletes are typically relatively older (e.g., Chittle et al., 2016; Dixon et al., 2013).

Consistent with other RAE football studies (e.g., Daniel & Janssen, 1987; Stanaway & Hines, 1995), no RAE was seen among the overall or delayed sub-samples of CIS football players. A significant RAE was seen among the on-time football players, although this only represents 13.61% of these athletes, as the vast majority of these individuals are delayed in some capacity. Similar to previous findings in soccer (e.g., Helsen et al., 1998; Musch & Hay, 1999; Vincent & Glamser, 2006), RAEs were seen among the overall samples of female and male CIS soccer players, those soccer players who were considered on-time, as well male soccer players who were delayed. Strong RAEs were also witnessed among the overall sample of male and female volleyball players, as well as those considered on-time.

While limited RAE research has been dedicated to individual sports, the current study provides some insight into the state of RAEs within track and field. Firstly, a slight overrepresentation of male on-time athletes born in the first half of the year (56.92%) was noted. Although this may not be entirely indicative of a relative age problem, there appears to be a trend occurring within this sport. Since past research in this sport focused only on 60 meter sprints (Romann & Cobley, 2015) it is difficult to draw any comparisons given that CIS track and field includes a number of different events (e.g., running, jumping, and throwing), and this study did not differentiate between them. A reverse in the RAE was seen among delayed females, whereby 46.05% of athletes were born in the first six months of the year, compared to 53.95% in the latter half. This trend supports other AT findings that have indicated delayed athletes are more commonly relatively younger (e.g., Chittle et al., 2016; Dixon et al., 2013). The differences in birthdate distributions that can be seen across sport, sex, and AT status provide support for Wattie et al.'s (2015) model that RAE profiles are influenced by individual, task, and environmental constraints.

Binary Logistic Regression Summary

When considering all student-athletes (i.e., the overall regression model), sex and quartile of birth are independent predictors of AT status. After accounting for quartile of birth, sex is significantly associated with AT. Specifically, CIS male student-athletes are 4.17 times more likely than female student-athletes to be delayed than on-time. Quartile of birth is also significantly associated with AT, once gender has been controlled for. Generally, those born in the early months of the year are less likely to be delayed than on-time. For example, those born in Q1, Q2, and Q3 are 42%, 38%, and 33% less likely than those born in Q4 to be delayed than on-time, respectively.

For the subgroup regression models (i.e., regression models by sport), six of the nine sports had models that were significantly different from the constant only models. For cross country, field hockey, and rugby the models that included the variables were not significantly different than the constant only models. All subgroup analyses that included sex as a variable found it to be significantly associated with AT, with females being less likely than males to be delayed than on-time. The greatest discrepancy was seen in ice hockey and basketball, whereby males are 1,000 and 4.35 times more likely than females to be delayed than on-time, respectively. Consistent with the overall regression model, quartile of birth was a significant predictor of AT for nearly all of the subgroup analyses. Generally, within these subgroup models, the earlier in the selection year that someone was born, the less likely he or she is to be delayed than on-time. This trend is strongest in football, where those born in Q1 are 57% less likely than those born in Q4 to be delayed than on-time.

The sensitivity and specificity values of the overall regression model indicated that it is better at correctly predicting those who are delayed than on-time. This may be explained by the over-representation (57.52%) of student-athletes who are delayed in the overall model. The subgroup models for ice hockey and volleyball generated high sensitivity values (as seen in Table 5) of 99.55% and 94.86%, respectively. This implies that these models are effective at correctly identifying on-time student-athletes. Alternatively, football, ice hockey, and track and field were effective at correctly identifying delayed student-athletes, with specificity values of 100.00%, 81.37%, and 72.99%, respectively. Ice hockey and football may have high specificity values due to the large number of student-athletes in these sports who are delayed (85.21% and 99.76%, respectively). As a result of the limited research examining the moderating effects of AT on the RAE, these regression models are exploratory and the first attempt by researchers to predict AT from sex and birth quartile. In the future, it may be beneficial to conduct a stepwise regression analysis to determine what other variables can be used to predict AT. While I propose that AT is an environmental constraint according to Wattie et al.'s (2015) model, various individual (e.g., physical maturation) and task constraints (e.g., sport physicality) are also likely to influence whether a student-athlete is delayed or on-time.

General Discussion

In an attempt to equalize opportunities among all individuals, researchers have proposed a variety of solutions to help minimize and mitigate the RAE problem. Solutions include rotating the annual cut-off date each year (Barnsley & Thompson, 1988; Barnsley et al., 1985; Musch & Grondin, 2001), implementing quota systems to ensure an equal proportion of relatively younger and older athletes (Barnsley & Thompson, 1988; Musch & Grondin, 2001), and grouping athletes based on their biological ages and/or anthropometric measurements (e.g., height and weight) to help ensure developmental similarities among competitors (Barnsley & Thompson, 1988; Musch & Grondin, 2001). In lieu of such solutions being actively implemented by sport governing bodies, there is a growing risk of relatively younger athletes dropping out of sport as a result of relative age. Furthermore, preventing athlete dropout may help to enhance talent identification programs by keeping talented, relatively younger athletes involved in sport, ultimately leading to better professional and national sport teams (Baker et al., 2010; Musch & Grondin, 2001). Despite these solutions being well thought-out, they seem to be specific to youth sport, and would be difficult to implement within an interuniversity/intercollegiate environment (Chittle et al., 2016).

The results of this study suggest that delaying one’s interuniversity sport career may be a method to overcome the age bias that relatively younger athletes experience given that only a moderate RAE with a small effect size was witnessed among the overall sample of male and female student-athletes. Utilizing redshirts and/or other methods to delay eligibility may provide relatively younger student-athletes with anywhere from a one to twelve month advantage over their otherwise older peers. The idea of delaying is not without precedent, given the prominence of parents holding their children back from beginning kindergarten on-time in order to gain athletic and/or academic advantages (Deming & Dynarski, 2008; Dickert-Conlin & Elder, 2010). This 'academic redshirting' is common among affluent, white, highly educated parents who can assume the additional childcare expenses (Deming & Dynarski, 2008). Such actions are contributing to the 'graying of kindergarten,' whereby students are starting school at older ages (Graue & DiPerna, 2000).

Despite the potential advantages associated with delay, there are also disadvantages that can arise. Firstly, being held back in school can translate into delayed entry into the workforce and, consequently, lost wages (Eide & Goldhaber, 2005). Furthermore, the ability to hold a child back from commencing kindergarten is a benefit that not all families can afford; therefore, this opportunity is not presented to all households, resulting in a bias in the children who become delayed (i.e., those from affluent, white, highly educated parents; Deming & Dynarski, 2008). Furthermore, it is important to keep in mind that the positive outcomes that can be associated with delaying only occur so long as all student-athletes do not seek out the same advantage (Dixon et al. 2013). Male CIS ice hockey provides a notable example of this, where nearly all these student-athletes are delayed, resulting in a strong RAE being present among these athletes. In this case, there is no advantage to be gained by relatively younger student-athletes who delay because virtually all male ice hockey players are also delayed in some capacity.

Since there is only a slight overall birthdate bias towards those born in the early months of the year for CIS male and female student-athletes, this could be an example of an athletic system that has nearly overcome the problems associated with relative age. Through the use of redshirting and/or other methods of delay, the CIS may have inadvertently neutralized the RAE that has plagued countless sports and competitive levels. However, if delaying becomes commonplace among student-athletes, the CIS may wish to implement eligibility age restriction policies to discourage and/or limit this from occurring.

Effective in 2014-2015, CIS introduced a policy change in football, whereby student-athletes must now be 24 years of age or younger, as of December 31st, in order to participate (CIS, n.d.). Although the data for the current study were collected prior to this policy implementation, this change will provide a unique perspective on CIS football moving forward. Based on the data collected for this study, only 13.61% of student-athletes in football were on-time, with some student-athletes being as many as 12 years delayed. While it is difficult to know precisely why so many of these athletes are delayed, it could be a result of other types of football development systems (e.g., Canadian Junior Football League) available to compete in, aside from CIS. Nonetheless, the 2014-2015 age restriction policy would have prevented many of these football players from using their full five years of athletic eligibility had it been present in the 2013-2014 season. This type of age restriction policy helps to ensure that those progressing to CIS from high school are not unduly disadvantaged and competing against much older athletes for positions on interuniversity teams.

Given that only two CIS male ice hockey players in this season were on-time, it raises the question as to whether an age restriction policy should be implemented in men's ice hockey as well. This argument is strengthened when considering that these athletes ranged from one to nine years delayed, with the vast majority of them delayed by three years (71.8%). If a comparable eligibility age restriction rule was employed in CIS ice hockey, very few athletes would be able to use their full five years of athletic eligibility before turning 24 (Chittle, Horton, & Dixon, 2015). It is likely that many of these student-athletes are delayed due to their participation in the Canadian Hockey League (CHL) prior to CIS. Based on information provided on the CIS eligibility certificates, 40% of these student-athletes previously competed in the CHL or another semi-professional league; however, this number is likely a gross underrepresentation given the limited number of universities that provided this information on their eligibility certificates. As suggested by Chittle et al. (2015), to curtail excessive delay, CIS may want to consider a comparable policy to NCAA Division I ice hockey, which prevents former CHL players from participating (subject to a possible appeal for restoration of eligibility) due to the CHL being considered a professional league (National Collegiate Athletic Association [NCAA], 2014). As an alternative, Chittle et al. (2015) proposed having ex-CHL ice hockey players lose one year of CIS eligibility for each year they competed in the CHL, which resembles the current policy employed in NCAA Division II and III (NCAA, 2013a; NCAA, 2013b).

Contrary to their CIS male counterparts, more female student-athletes are on-time than delayed. This may be due, in part, to there being fewer developmental leagues available for female athletes to compete in after high school when compared to males. For example, 67.28% of CIS female ice hockey players are on-time compared to only 0.24% of men. Since there is no female equivalent to the CHL, many of the top female ice hockey players choose to attend either a CIS member institution or compete in the NCAA (Chittle et al., 2015). As of 2012-2013, 37.3% of Division I female ice hockey players were Canadian (Edwards & Lohnes, 2014). In an attempt to keep the highest calibre female ice hockey players competing in Canada, CIS recently implemented a five-year pilot project that allows CIS women's ice hockey programs to offer athletic scholarships that can defray costs beyond tuition and compulsory fees (CIS, 2013). While there is currently a RAE among CIS female ice hockey players, this trend is likely to strengthen in future years if we assume that such policy changes will help to keep the best athletes (who are presumably relatively older in the first place) in Canada (Chittle et al., 2015).

Furthermore, a new eligibility repatriation rule has been implemented which allows Canadian student-athletes participating in the NCAA to return to CIS member institutions and compete immediately, without having to redshirt for a year (CIS, 2013). Given that many of these student-athletes who transferred from NCAA to CIS would have previously redshirted upon returning to Canada, this policy change is likely to influence the birthdate distribution of on-time female ice hockey players, as fewer of them would be classified as delayed given that redshirting may no longer be necessary.

Knowing the current state of relative age in CIS sport, as well as the potential moderating effects of AT on interuniversity sport participation, may help guide and inform future policy decisions to optimize fairness among all student-athletes. While this discussion presents the most extreme examples, the impact of the RAE and AT is sport-specific; thus, future policy decisions should also be sport-specific.

Limitations and Future Directions

A limitation in this study is the inability to determine the precise reason why student-athletes are delayed in their athletic eligibilities. Given that 73.33% of male and 39.50% of female student-athletes are delayed, it would be valuable for future researchers to explore the causes of these delays through qualitative interviews and/or a mixed methods approach. This would help to elucidate whether student-athletes are deliberately delaying themselves in order to gain an athletic advantage or if this is an unintended benefit of being held back earlier in their educational careers (Dixon et al., 2013).

A second limitation to this study is being unable to identify the birth dates of some student-athletes. This trend was often consistent across certain institutions whose eligibility certificates did not contain this information. While the current study is representative of CIS student-athletes and provides information relating to the general state of the RAE in CIS, it is not entirely comprehensive. Therefore, the birthdate distribution across the CIS as a whole and by sport may change somewhat if athletes who were removed due to missing birthdate information were included. Moreover, given that the CIS eligibility certificates are completed at each local institution, the information used in this study is only as accurate as what is provided on these certificates. Despite the potential for human errors in completing these eligibility certificates, they are likely to have occurred at random and would not change the outcome of the results. In the future, it would be beneficial for CIS to create a standardized eligibility certificate template for all universities to complete to help ensure all institutions are providing the same information in the same format. Doing so would allow consistent information to be collected, leading to more accurate statistical analyses and records of student-athletes. Furthermore, using an electronic roster template that is compatible with standard statistical programs (e.g., SPSS) would allow CIS to quickly generate descriptive and other statistical information that could be used as a foundation for future policy decisions.

Finally, as with previous studies examining AT (e.g., Chittle et al., 2015; Chittle et al., 2016), this analysis could have benefited from using the birth distribution of the general student population attending CIS member institutions as the basis for the comparisons, given that previous research has indicated RAEs may be present among those attending university (e.g., Bedard & Dhuey, 2006). In lieu of this information being readily available, Canadian population birth rates served as the next best comparison.

Given that there is limited RAE research on many CIS championship sports (e.g., field hockey, cross country) replication studies ought to be conducted in these sports to determine the state of the RAE at different competitive levels and age groups. A longitudinal study examining the role of AT on the RAE across a number of CIS seasons would help highlight how the birth distribution of student-athletes may change over time, particularly in light of these recent CIS policy changes.

This study adds to the existing body of literature by providing a comprehensive overview of the state of the RAE in a number of sports, across both sexes, and presents the moderating effects that AT can have on participation in CIS. There is a paucity of investigations dedicated to individual sports and this study attempts to address this by examining the RAE in cross country and track and field. Given that most RAE studies are univariate in nature, the multivariate analyses conducted in this study provide examples of alternative, more robust statistical approaches that can be utilized. Furthermore, it highlights the need for multivariate statistical techniques in order to account for the multiple constraints that can influence RAE profiles.

Conclusion

The RAE is a systemic bias that discriminates against those who are born later in the year relative to a particular selection date. Academic timing is an important factor to consider when examining the RAE in interuniversity sport. Failing to consider this moderator can result in a skewed perception of the bias associated with relative age. Within CIS, 73.33% of male student-athletes are delayed in some capacity with the most extreme examples being ice hockey and football where 99.76% and 85.21% of these players are delayed, respectively. It appears within these sports that delaying athletic eligibility has become commonplace. Alternatively, only 39.50% of CIS female student-athletes are delayed. The disparity in these values may be due to fewer opportunities for females to partake in competitive sport outside of interuniversity athletics. Delaying one’s athletic eligibility may be a means to equalize playing opportunities for those who are relatively younger; however it appears to be ubiquitous in some sports. In the future, CIS policy makers may want to consider the influence of AT on the student-athlete population in order to ensure all student-athletes have equal opportunities to benefit from participation in CIS.

References

Addona, V., & Yates, P. A. (2010). A closer look at the relative age effect in the National Hockey League. *Journal of Quantitative Analysis in Sports, 6*(4), 1-17. doi:10.2202/1559-0410.1227

Armstrong, H. G. (1966). A comparison of the performance of summer and autumn-born children at eleven and sixteen. *British Journal of Educational Psychology, 36*(1), 72-76. doi: 10.1111/j.2044-8279.1966.tb01841.x

Baker, J., Schorer, J., & Cobley, S. (2010). Relative age effects: An inevitable consequence of elite sport? *Sportwissenschaft, 40*(1), 26-30. doi: 10.1007/s12662-009-0095-2

Baker, J., Schorer, J., Cobley, S., Bräutigam, H., & Büsch, D. (2009). Gender, depth of competition and relative age effects in team sports. *Asian Journal of Exercise & Sports Science*, *6*(1), 1-7.

Barnsley, R. H., & Thompson, A. H. (1988). Birthdate and success in minor hockey: The key to the NHL. *Canadian Journal of Behavioural Science, 20*(2), 167-176. http://dx.doi.org/10.1037/h0079927

Barnsley, R. H., Thompson, A. H., & Barnsley, P. E. (1985). Hockey success and birthdate: The RAE. *Canadian Association for Health, Physical Education, and Recreation, 51*, 23-28.

Baxter-Jones, A. & Helms, P. (1994). Born too late to win? *Nature, 370*(6486), 186. doi:10.1038/370186b0

Baxter-Jones, A., Helms, P., Baines-Preece, J., & Preece, M. (1994). Growth and development of male athletes: Implications for identification of talent. *Journal of*

Sport Sciences, 12, 156.

Bedard, K., & Dhuey, E. (2006). The persistence of early childhood maturity: International evidence of long-run age effects. *The Quarterly Journal of Economics*, *121*(4), 1437-1474.

Brady, P., & Allingham, P. (2010). Pathways to university: The "victory lap" phenomenon in Ontario. *Canadian Journal of Educational Administration and Policy, 113*, 1-25.

Buckles, K. S., & Hungerman, D. M. (2013). Season of birth and later outcomes: Old questions, new answers. *The Review of Economics and Statistics, 95*(3), 711-724. doi:10.1162/REST_a_00314

Canadian Interuniversity Sport. (n.d.). *Athlete's guide*. Retrieved from http://english.cis-sic.ca/information/members_info/pdfs/pdf_elig_pack/13-14/athletes_guide.pdf

Canadian Interuniversity Sport. (2013). *Trio of motions move Canadian university sport into a new territory*. Retrieved from http://english.cis-sic.ca/sports/cis_news/2013-14/releases/20131126-cis

CBS Interactive (2012). Redshirting: Holding kids back from kindergarten. *60 Minutes*. Retrieved from http://www.cbsnews.com/8301-18560_162-57390128/redshirting-holding-kids-back-from kindergarten/?pageNum=5&tag=contentMain;contentBody

Chittle, L., Horton, S., & Dixon, J. C. (2016). Time out or fast break? Relative age effect in NCAA Division I basketball. *Journal of Sport Behavior*, *39*(2), 107-125.

Chittle, L., Horton, S., & Dixon, J.C. (2015). Exploring the relative age effect in Canadian interuniversity ice hockey. *Talent Development & Excellence, 7*(1), 69-81.

Cobley, S., Abraham, C., & Baker, J. (2008). Relative age effects on physical education attainment and school sport representation. *Physical Education and Sport Pedagogy, 13*(3), 267-276. doi: 10.1080/17408980701711983

Cobley, S., Baker, J., Wattie, N., & McKenna, J. M. (2009a). How pervasive are relative age effects in secondary school education? *Journal of Educational Psychology, 101*(2), 520- 528. http://dx.doi.org/10.1037/a0013845

Cobley, S., Baker, J., Wattie, N., & McKenna, J. M. (2009b). Annual age-grouping and athlete development: A meta-analytic review of relative age effects in sport. *Sports Medicine, 39*(3), 235-256.

Cobley, S., Hanratty, M., O'Connor, D., & Cotton, W. (2014). First club location and relative age influences on being a professional Australian Rugby League Player. *International Journal of Sports Science & Coaching, 9*(2), 335-346. doi: 10.1260/1747-9541.9.2.335

Cobley, S. P., Schorer, J., & Baker, J. (2008). Relative age effects in professional German soccer: A historical analysis. *Journal of Sports Sciences*, *26*(14), 1531-1538. doi: 10.1080/02640410802298250

Cohen, J. (1992). Statistical power analysis. *Current Directions in Psychological Science*, *1*(3), 98-101.

Costa, A. M., Marques, M. C., Louro, H., Ferreira, S. S., & Marinho, D. A. (2013). The relative age effect among elite youth competitive swimmers. *European Journal of Sport Science, 13*(5), 437-444. doi: 10.1080/17461391.2012.742571

Côté, J., MacDonald, D. J., Baker, J., & Abernethy, B. (2006). When ‘where’ is more important than ‘when’: Birthplace and birthdate effects on the achievement of sporting expertise. *Journal of Sports Sciences, 24*(10), 1065-1073. doi: 10.1080/02640410500432490

Cowgill, U. M. (1966). Season of birth in man. Contemporary situation with special reference to Europe and the Southern hemisphere. *Ecology, 47*, 614-623. doi:10.2307/1933939

Daniel, T. E., & Janssen, C. T. L., (1987). More on the relative age effect. *CAHPER-ACSEPL Journal, 53*(2), 21-24.

Delorme, N., Boiché, J., & Raspaud, M. (2009). The relative age effect in elite sport: The French case. *Research Quarterly for Exercise and Sport, 80*(2), 336–344. doi: 10.1080/02701367.2009.10599568

Delorme, N., Boiché, J., & Raspaud, M. (2010). Relative age effect in female sport: A diachronic examination of soccer players. *Scandinavian Journal of Medicine & Science in Sports, 20*, 509-515. doi: 10.1111/j.1600-0838.2009.00979.x

Delorme, N & Champely, S. (2015). Relative age effect and chi-squared statistics. *International Review for the Sociology of Sport, 50*(6), 740-746.

Delorme, N., & Raspaud, M. (2009). The relative age effect in young French basketball players: A study on the whole population. *Scandinavian Journal of Medicine & Science in Sports, 19*(2), 235–242. doi: 10.1111/j.1600-0838.2008.00781.x

Deming, J. D., & Dynarski, S. (2008). The lengthening of childhood. *Journal of Economic Perspectives*, *22*(3), 71–92.

Dickert-Conlin, S., & T. Elder. (2010). Suburban legend: School cutoff dates and the timing of births. *Economics of Education Review*, *29*, 826–41. doi:10.1016/j.econedurev.2010.03.004

Dixon, J. C., Horton, S., & Weir, P. (2011). Relative age effects: Implications for leadership development. *International Journal of Sport and Society, 2*(2), 1-15.

Dixon, J. C., Liburdi, V., Horton, S, & Weir, P. (2013). An examination of the impact of relative age effects and academic timing on intercollegiate athletics participation in women's softball. *Journal of Intercollegiate Sports, 6*, 147-163.

Edwards, J., & Lohnes, C. (2014, June). *Closing the gap: Exploring the strategies used by the NCAA Division I schools to recruit international female hockey players.* Paper presented at The Hockey Conference, London, Ontario. Abstract retrieved from http://www.thehockeyconference.ca/wp-content/uploads/ 2014/06/The-Hockey-Conference-Abstracts-Western-Univesity-June-2014.pdf

Eide, E. R., & Goldhaber, D. D. (2005). Grade retention: What are the costs and benefits? *Journal of Education Finance, 31*(2), 195-214.

Esteva, S., & Drobnic, F. (2006). Birthdate and basketball success. *FIBA Assist Magazine*, *18*, 64-66.

Freyman, R. (1965). Further evidence on the effect of date of birth on subsequent school performance. *Educational Research, 8*, 58-64. doi:10.1080/0013188650080105

García, M. S., Aguilar, O. G., Romero, J. J. F., Lastra, D. F., & Oliveira, G. E. (2014). Relative age effect in lower categories of international basketball. *International*

Review for the Sociology of Sport, 49(5), 526-535. doi:10.1177/1012690212462832

Gladwell, M. (2008). *Outliers: The story of success.* New York, NY: Little, Brown and Company.

Glamser, F. D., & Marciani, L. M. (1992). The birthdate effect and college athletic participation: Some comparisons. *Journal of Sport Behavior, 15*(3), 227-238.

Graue, M. E. & DiPerna, J. (2000). Redshirting and early retention: Who gets the "gift of time" and what are the outcomes. *American Educational Research Journal, 37*(2), 509-534.

Grondin, S., Deschaies, P., & Nault, L. P. (1984). Trimestres de naissance et participation au hockey et au volleyball. *La Revue Québecoise de l'Activité Physique, 2*, 97-103.

Hancock, D. J., Ste-Marie, D. M., & Young, B. W. (2013). Coach selections and the relative age effect in male youth ice hockey. *Research Quarterly for Exercise and Sport, 84*(1), 126-130. doi: 10.1080/02701367.2013.762325

Helsen, W. F., Starkes, J. L., & Van Winckel, J. (1998). The influence of relative age on success and dropout in male soccer players. *American Journal of Human Biology, 10,* 791-798.

Human Fertility Database. (2013). *Total number of live births.* Retrieved from http://www.humanfertility.org/cgi-bin/country.php?country=CAN&update=20131001

Lidor, R., Arnon, M., Maaya, Z., Gershon, & Côté, J. (2014). Relative age effect and birthplace effect in Division I female ballgame players- the relevance of sport-specific factors. *International Journal of Sport and Exercise Psychology, 12*(1), 19-33.

MacDonald, D. J., Cheung, M., Côté, J., & Abernethy, B. (2009). Place but not date of birth influences the development and emergence of athletic talent in American football. *Journal of Applied Sport Psychology, 21*(1)*,* 80-90. doi: 10.1080/10413200802541868

Montelpare, W. J., Scott, D., & Pelino, M. (2000). Tracking the relative age effect across minor, amateur and professional ice-hockey leagues. In A. B. Ashare (Ed.), *Safety in ice hockey* (Vol. 3, pp. 250-260). Philadelphia, PA: American Society for Testing and Materials.

Musch, J., & Grondin, S. (2001). Unequal competition as an impediment to personal development: A review of the relative age effect in sport. *Developmental Review, 21*, 147-167.

Musch, J., & Hay, R. (1999). The relative age effect in soccer: Cross-cultural evidence for a systematic discrimination against children born late in the competition year. *Sociology of Sport Journal, 16*, 54-64.

Nakata, H., & Sakamoto, K. (2011). Relative age effect in Japanese male athletes. *Perceptual and Motor Skills, 113*(2), 570-574. doi: 10.2466/05.10.11.PMS.113.5.570-574

National Collegiate Athletic Association (2013a). *Division II Manual: 2013-2014.* Retrieved from http://www.ncaapublications.com/productdownloads/D214.pdf

National Collegiate Athletic Association (2013b). *Division III Manual: 2013-2014.* Retrieved from http://www.ncaapublications.com/productdownloads/D314.pdf

National Collegiate Athletic Association (2014). *Division I Manual: 2013-2014*. Retrieved from http://www.ncaapublications.com/productdownloads/D114APR.pdf

Nolan, J. E., & Howell, G. (2010). Hockey success and birth date: The relative age effect revisited. *International Review for the Sociology of Sport, 45*(4), 507-512. doi: 10.1177/1012690210371560

Raschner, C., Müller, L., & Hildebrandt, C. (2012). The role of a relative age effect in the first Youth Olympic Games in 2012. *British Journal of Sports Medicine, 46,* 1038-1043. doi:10.1136/bjsports-2012-091535

Roberts, S. J., & Fairclough, S. J. (2012). The influence of relative age effects in representative youth rugby union in the north west of England. *Asian Journal of Exercise & Sport Science, 9*(2), 86-98.

Romann, M., & Cobley, S. (2015). Relative age effects in athletic sprinting and corrective adjustments as a solution for their removal. *PLoS One, 10*(4), e0122988. doi: 10.1371/journal.pone.0122988

Schorer, J., Neumann, J., Cobley, S. P., Tietjens, M., & Baker, J. (2011). Lingering effects of relative age in basketball players' post athletic careers. *International Journal of Sports Science & Coaching, 6*(1), 143-147. doi: 10.1260/1747-9541.6.1.143

Smith, J. (2009). Can regression discontinuity help answer an age-old question in education? The effect of age on elementary and secondary school achievement. *The B. E. Journal of Economic Analysis & Policy*, *9*(1), 1-28.

Stanaway, K. B., & Hines, T. M. (1995). Lack of season of birth effect among American athletes. *Perceptual and Motor Skills, 81*, 952-954. doi: 10.2466/pms.1995.81.3.952

Stevens, J. P. (2009). *Applied multivariate statistics for the social sciences* (5th ed.). New York, NY: Taylor & Francis Group.

Tabachnick, B. G., & Fidell, L. S. (1996). *Using multivariate statistics* (3rd ed.). New York: HarperCollins.

Till, K., Cobley, S., Wattie, N., O'Hara, J. Cooke, C., & Chapman, C. (2010). The prevalence, influential factor and mechanisms of relative age effect in UK Rugby League. *Scandinavian Journal of Medicine & Science in Sports, 20*(2), 320-329. doi: 10.1111/j.1600-0838.2009.00884.x

Vincent, J., & Glamser, F. D. (2006). Gender differences in the relative age effect among US Olympic development program youth soccer players. *Journal of Sports Sciences*, *24*(4), 405-413. doi: 10.1080/02640410500244655

Wattie, N., Schorer, J., & Baker, J. (2015). The relative age effect in sport: A developmental systems model. *Sports Medicine*, *45*(1), 83-94. doi: 10.1007/s40279-014-0248-9

Weir, P. L., Smith, K. L., Paterson, C., & Horton, S. (2010). Canadian women's ice hockey - evidence of a relative age effect. *Talent Development & Excellence, 2*(2), 209-217.

Wilson, G. (1999). The birthdate effect in school sports teams. *European Journal of Physical Education, 4*(2), 139-145. doi: 10.1080/1740898990040203

Table 1

Summary of National Sport Organization Cut-off Dates

Sport	Cut-off Date
Basketball	January 1st
Cross Country	December 31st
Curling	N/A
Field Hockey	December 31st
Football	December 31st
Ice Hockey	December 31st
Rugby	December 31st
Soccer	December 31st
Swimming	N/A
Track & Field	December 31st
Wrestling	N/A
Volleyball	December 31st

Note. The national governing bodies in Canada for curling, swimming and wrestling do not use an annual cut-off date to group athletes.

Table 2

Descriptive Statistics for On-time, Delayed, and Advanced CIS Student-Athletes

Sport	Gender	On-time (%)	Delayed (%)	Advanced (%)	Range Delay (years)	1 Year Delayed (%)	2 Years Delayed (%)	3 Years Delayed (%)	4 Years Delayed (%)	5+ Years Delayed (%)
All Sports	Total									
	Male	25.33	73.33	1.35	1-18	24.46	18.36	20.53	6.02	3.95
	Female	56.76	39.50	3.74	1-22	20.74	9.52	4.63	2.13	2.47
Basketball	Total									
	Male	29.06	69.01	1.94	1-7	36.32	17.19	8.47	3.87	3.15
	Female	62.23	35.84	1.94	1-8	20.10	9.69	3.87	1.45	0.73
Cross Country	Total									
	Male	37.63	61.36	1.02	1-10	24.41	14.58	10.17	7.12	5.08
	Female	33.01	64.38	2.61	1-22	27.45	14.05	9.48	3.59	9.80
Field Hockey	Total									
	Female	55.44	37.31	7.25	1-9	18.65	11.40	2.59	3.63	1.04
Football	Total									
	Male	13.61	85.21	1.18	1-12	30.76	30.97	14.03	5.35	4.10
Ice Hockey	Total									
	Male	0.24	99.76	0	1-9	2.16	10.46	71.75	11.66	3.73
	Female	67.28	29.19	3.53	1-17	17.36	5.53	3.53	1.69	1.08
Rugby	Total									
	Female	44.76	51.08	4.16	1-10	26.26	13.34	5.02	2.73	3.73
Soccer	Total									
	Male	40.85	56.71	2.44	1-11	28.29	12.93	6.34	4.51	4.63
	Female	61.48	33.64	4.88	1-10	17.58	7.93	5.08	1.63	1.42

Sport	Gender	On-time (%)	Delayed (%)	Advanced (%)	Range Delay (years)	1 Year Delayed (%)	2 Years Delayed (%)	3 Years Delayed (%)	4 Years Delayed (%)	5+ Years Delayed (%)
Track & Field	Total									
	Male	40.54	57.21	2.24	1-18	27.72	12.34	7.69	5.13	4.33
	Female	50.41	46.34	3.25	1-11	24.39	10.98	4.67	3.05	3.25
Volleyball	Total									
	Male	56.67	42.73	0.61	1-9	22.73	13.03	3.64	1.82	1.52
	Female	68.89	28.80	2.30	1-13	16.82	7.14	2.76	0.92	1.15

Table 3

Summary of Relative Age Results for CIS using a Chi-Square Goodness of Fit Test

Sport	Gender	n [a]	$M_{age}(SD)$ [b,c]	$X^2(df)$	φ	Q1		Q2		Q3		Q4	
						%	z	%	z	%	z	%	z
All Sports	Total												
	Male	4754	21.07(1.96)	67.84(3)*	$0.12^{\dagger}$	28.82	6.34*	26.90	0.83	23.77	-2.77*	20.51	-4.40*
	Female	4170	20.10(1.90)	40.87(3)*	$0.10^{\dagger}$	26.52	2.93*	28.90	3.28*	24.00	-2.30*	20.58	-4.03*
	On-Time												
	Male	1204	19.37(1.29)	61.54(3)*	$0.23^{\dagger}$	31.98	5.41*	28.65	1.60	22.84	-2.03*	16.53	-5.06*
	Female	2367	19.33(1.29)	72.96(3)*	$0.18^{\dagger}$	27.71	3.38*	30.46	3.96*	24.93	-0.85	16.90	-6.72*
	Delayed												
	Male	3486	21.70(1.77)	22.53(3)*	0.08	27.54	3.89*	26.28	-0.02	24.15	-1.92	22.03	-1.92
	Female	1647	21.32(2.02)	11.75(3)*	0.08	23.50	-0.65	27.08	0.62	22.95	-2.28*	26.47	2.39*
	Advanced												
	Male	64	18.92(1.52)	9.93(3)*	$0.39^{\dagger\dagger}$	39.06	2.41*	28.13	0.29	20.31	-0.86	12.5	-1.83
	Female	156	18.89(1.38)	24.14(3)*	$0.39^{\dagger\dagger}$	40.38	4.08*	24.36	-0.47	21.15	-1.15	14.10	-2.44*
Basketball	Total												
	Male	413	20.78(1.90)	8.47(3)*	$0.14^{\dagger}$	29.78	2.27*	25.18	-0.44	25.67	-0.06	19.37	-1.77
	Female	413	20.06(1.77)	7.23(3)	$0.13^{\dagger}$	29.78	---	23.00	---	24.70	---	22.52	---
	On-Time												
	Male	120	19.57(1.32)	10.26(3)*	$0.29^{\dagger}$	32.50	1.84	30.0	0.80	25.0	-0.18	12.50	-2.50*
	Female	257	19.43(1.36)	5.74(3)	$0.15^{\dagger}$	29.57	---	25.29	---	26.46	---	18.68	---
	Delayed												
	Male	285	21.34(1.86)	2.93(3)	$0.10^{\dagger}$	28.07	---	23.16	---	26.32	---	22.46	---
	Female	148	21.26(1.77)	6.89(3)	$0.22^{\dagger}$	28.38	---	18.92	---	22.97	---	29.73	---

Notes. * = $p < 0.05$; † = small effect size, †† = medium effect size, ††† = large effect size.
[a]The Total sample sizes include those who are on-time, delayed, and advanced. [b]All ages were calculated as of December 31st, 2013.
[c]For each individual sport, the mean age for the overall group of student-athletes includes those athletes classified as advanced.

Sport	Gender	n^a	$M_{age}(SD)^{b,c}$	$X^2(df)$	φ	Q1		Q2		Q3		Q4	
						%	z	%	z	%	z	%	z
Cross Country	Total												
	Male	295	20.73(1.92)	2.00(3)	0.08	25.76	---	23.73	---	24.41	---	26.10	---
	Female	306	20.86(2.75)	7.83(3)*	$0.16^{\dagger}$	20.59	-1.31	32.03	1.96*	21.90	-1.35	25.49	0.68
	On-Time												
	Male	111	19.53(1.24)	4.25(3)	$0.20^{\dagger}$	32.43	---	21.62	---	23.42	---	22.52	---
	Female	101	19.15(1.25)	4.57(3)	$0.21^{\dagger}$	17.82	---	34.65	---	25.74	---	21.78	---
	Delayed												
	Male	181	21.50(1.87)	2.31(3)	$0.11^{\dagger}$	21.55	---	24.86	---	25.41	---	28.18	---
	Female	197	21.84(2.87)	5.88(3)	$0.17^{\dagger}$	21.32	---	30.46	---	20.30	---	27.92	---
Field Hockey	Total												
	Female	193	20.12(1.74)	1.14(3)	0.08	25.91	---	28.50	---	23.83	---	21.76	---
	On-Time												
	Female	107	19.48(1.31)	2.57(3)	$0.16^{\dagger}$	26.17	---	31.78	---	22.43	---	19.63	---
	Delayed												
	Female	72	21.33(1.73)	0.74(3)	$0.10^{\dagger}$	20.83	---	25	---	27.78	---	26.39	---
Football	Total												
	Male	1440	21.18(1.76)	0.26(3)	0.01	24.17	---	26.04	---	26.39	---	23.40	---
	On-Time												
	Male	196	19.27(1.33)	16.37(3)*	$0.29^{\dagger}$	34.69	2.96*	29.08	0.77	19.90	-1.63	16.33	-2.10*
	Delayed												
	Male	1227	21.52(1.61)	4.33(3)	0.06	22.33	---	25.43	---	27.55	---	24.69	---

Notes. * = $p < 0.05$; † = small effect size, †† = medium effect size, ††† = large effect size.
[a]The Total sample sizes include those who are on-time, delayed, and advanced. [b]All ages were calculated as of December 31st, 2013.
[c]For each individual sport, the mean age for the overall group of student-athletes includes those athletes classified as advanced.

Sport	Gender	n^a	$M_{age}(SD)^{b,c}$	$X^2(df)$	φ	Q1		Q2		Q3		Q4	
						%	z	%	z	%	z	%	z
Ice Hockey	Total												
	Male	832	22.43(1.42)	79.25(3)*	0.31††	35.70	6.68*	28.73	1.37	19.47	-3.60*	16.11	-4.45*
	Female	651	19.99(1.82)	23.89(3)*	0.19†	28.88	2.38*	31.18	2.44*	21.81	-2.01*	18.13	-2.88*
	On-Time												
	Male	2	18.50(.71)	---	---	---	---	---	---	---	---	---	---
	Female	438	19.41(1.31)	23.48(3)*	0.23†	29.91	2.38*	31.96	2.31*	21.69	-1.69	16.44	-3.09*
	Delayed												
	Male	830	22.44(1.41)	79.14(3)*	0.31††	35.66	6.65*	28.80	1.41	19.52	-3.57*	16.02	-4.5*
	Female	190	21.33(2.13)	1.71(3)	0.09	25.79	---	28.95	---	22.11	---	23.16	---
Rugby	Total												
	Female	697	20.13(1.92)	5.43(3)	0.09	27.69	---	26.69	---	24.10	---	21.52	---
	On-Time												
	Female	312	19.11(1.15)	6.82(3)	0.15†	28.53	---	28.53	---	24.68	---	18.27	---
	Delayed												
	Female	356	21.14(1.95)	3.05(3)	0.09	27.53	---	24.44	---	23.31	---	24.72	---
Soccer	Total												
	Male	820	20.54(2.00)	27.58(3)*	0.18†	30.24	3.46*	28.17	1.05	24.27	-0.87	17.32	-3.71*
	Female	984	19.94(1.66)	20.66(3)*	0.14†	27.34	1.94	29.78	2.13*	24.59	-0.75	18.29	-3.43*
	On-Time												
	Male	335	19.30(1.27)	13.49*	0.20†	29.25	1.84	30.15	1.37	24.48	-0.48	16.12	-2.82*
	Female	605	19.35(1.28)	29.83(3)*	0.22†	28.43	2.06*	31.07	2.29*	25.79	-0.02	14.71	-4.50*
	Delayed												
	Male	465	21.49(1.92)	12.76*	0.17†	30.54	2.74*	26.67	0.16	24.09	-0.73	18.71	-2.18*
	Female	331	21.17(1.66)	2.98(3)	0.09	22.66	---	29.61	---	22.96	---	24.77	---

Notes. * = $p < 0.05$; † = small effect size, †† = medium effect size, ††† = large effect size.

[a]The Total sample sizes include those who are on-time, delayed, and advanced. [b]All ages were calculated as of December 31st, 2013.

[c]For each individual sport, the mean age for the overall group of student-athletes includes those athletes classified as advanced.

Sport	Gender	n^a	$M_{age}(SD)^{b,c}$	$X^2(df)$	φ	Q1		Q2		Q3		Q4	
						%	z	%	z	%	z	%	z
Track & Field	Total												
	Male	624	20.48(2.14)	6.95(3)	$0.11^{\dagger}$	28.69	---	24.84	---	23.40	---	23.08	---
	Female	492	20.14(1.97)	0.58(3)	0.03	23.98	---	27.44	---	24.59	---	23.98	---
	On-Time												
	Male	253	19.28(1.24)	10.89(3)*	$0.21^{\dagger}$	32.81	2.74*	24.11	-0.67	24.51	-0.41	18.58	-1.64
	Female	248	19.12(1.26)	4.34(3)	$0.13^{\dagger}$	28.23	---	27.02	---	26.21	---	18.55	---
	Delayed												
	Male	357	21.40(2.17)	3.13(3)	0.09	25.77	---	25.49	---	22.41	---	26.33	---
	Female	228	21.37(1.94)	9.45(3)*	$0.20^{\dagger}$	17.98	-1.93	28.07	0.53	23.25	-0.76	30.70	2.21*
Volleyball	Total												
	Male	330	20.29(1.81)	16.72(3)*	$0.23^{\dagger}$	30.00	2.10*	31.82	1.95	19.70	-2.19*	18.48	-1.91
	Female	434	20.02(1.70)	11.37(3)*	$0.16^{\dagger}$	23.50	-0.33	32.26	2.42*	26.04	0.09	18.20	-2.32*
	On-Time												
	Male	187	19.51(1.33)	21.87(3)*	$0.34^{\dagger\dagger}$	32.09	2.17*	35.29	2.40*	19.25	-1.77	13.37	-2.89*
	Female	299	19.53(1.32)	16.90(3)*	$0.24^{\dagger}$	24.08	-0.07	34.45	2.75*	26.42	0.20	15.05	-3.05*
	Delayed												
	Male	141	21.35(1.83)	2.04(3)	$0.12^{\dagger}$	26.24	---	27.66	---	20.57	---	25.53	---
	Female	125	21.32(1.83)	2.09(3)	$0.13^{\dagger}$	20.00	---	28.80	---	24.00	---	27.20	---

Notes. * = $p < 0.05$; † = small effect size, †† = medium effect size, ††† = large effect size.

[a]The Total sample sizes include those who are on-time, delayed, and advanced. [b]All ages were calculated as of December 31st, 2013.

[c]For each individual sport, the mean age for the overall group of student-athletes includes those athletes classified as advanced.

Table 4

Summary of Binary Logistic Regression Results

Predictor	*B*	*SE*	*Wald*	*p*	*Exp(B) (OR)*	*95% CI for OR*
All Sports*						
Female	-1.44	.047	953.68	< .001	.24	.22-.26
Male (Reference)	---	---	---	---	---	---
Q1	-.54	.069	61.08	< .001	.58	.51-.67
Q2	-.48	.069	49.88	< .001	.62	.54-.71
Q3	-.40	.071	31.41	< .001	.67	.58-.77
Q4 (Reference)	---	---	---	---	---	---
Constant	1.45	.060	595.90	< .001	4.27	---
Basketball*						
Female	-1.47	.15	92.28	< .001	.23	.17-.31
Male (Reference)	---	---	---	---	---	---
Q1	-.61	.22	7.69	< .01	.55	.36-.84
Q2	-.79	.23	11.90	< .01	.45	.29-.71
Q3	-.56	.23	6.21	.01	.57	.37-.89
Q4 (Reference)	---	---	---	---	---	---
Constant	1.40	.20	51.93	< .001	4.07	---
Cross Country						
Female	.17	.17	.97	.32	1.19	.85-1.67
Male (Reference)	---	---	---	---	---	---
Q1	-.40	.25	2.57	.11	.67	.41-1.09
Q2	-.25	.24	1.09	.30	.78	.49-1.25
Q3	-.31	.25	1.52	.22	.74	.45-1.20
Q4 (Reference)	---	---	---	---	---	---
Constant	.73	.20	14.03	< .001	2.07	---

Notes. *SE* = Standard Error. *OR* = Odds ratio. 95% *CI* = 95% Confidence Interval. Q1 = Quartile one. Q2 = Quartile two. Q3 = Quartile three. Q4 = Quartile four.
* The regression model that includes the variables is significantly different than the constant only model $p < 0.05$.

Predictor [a,b]	*B*	*SE*	*Wald*	*p*	*Exp(B) (OR)*	*95% CI for OR*
Field Hockey						
Q1	-.52	.45	1.36	.24	.59	.25-1.43
Q2	-.54	.43	1.55	.21	.59	.25-1.36
Q3	-.08	.44	.04	.85	.92	.39-2.17
Q4 (Reference)	---	---	---	---	---	---
Constant	-.10	.32	.10	.75	.91	---
Football*						
Q1	-.85	.23	13.80	< .001	.43	.27-.67
Q2	-.55	.24	5.43	.02	.58	.37-.92
Q3	-.09	.25	.12	.73	.92	.56-1.50
Q4 (Reference)	---	---	---	---	---	---
Constant	2.25	.19	146.27	< .001	9.47	---
Ice Hockey*						
Female	-6.90	.71	93.35	< .001	<.001	<.001-.004
Male (Reference)	---	---	---	---	---	---
Q1	-.47	.25	3.41	.07	.63	.38-1.03
Q2	-.40	.25	2.58	.11	.67	.41-1.09
Q3	-.28	.27	1.14	.29	.75	.45-1.27
Q4 (Reference)	---	---	---	---	---	---
Constant	6.38	.73	75.61	< .001	588.11	---
Rugby						
Q1	-.34	.22	2.27	.13	.71	.46-1.11
Q2	-.46	.23	4.05	.04	.63	.41-.99
Q3	-.36	.23	2.39	.12	.70	.44-1.10
Q4 (Reference)	---	---	---	---	---	---
Constant	.43	.17	6.52	.01	1.54	---

Notes. *SE*=Standard Error. *OR*=Odds ratio. 95% *CI*= 95% Confidence Interval. Q1= Quartile one. Q2= Quartile two. Q3= Quartile three. Q4= Quartile four.
[a]Field hockey and rugby only had female student-athletes competing. [b]Football only had male student-athletes competing.
* The regression model that includes the variables is significantly different than the constant only model $p < 0.05$.

Predictor	*B*	*SE*	*Wald*	*p*	*Exp(B) (OR)*	*95% CI for OR*
Soccer*						
Female	-.94	.10	89.24	< .001	.39	.32-.47
Male (Reference)	---	---	---	---	---	---
Q1	-.45	.15	8.89	< .01	.64	.48-.86
Q2	-.44	.15	8.92	< .01	.64	.48-.86
Q3	-.43	.15	7.76	< .01	.65	.48-.88
Q4 (Reference)	---	---	---	---	---	---
Constant	.69	.13	28.50	< .001	2.00	---
Track & Field*						
Female	-.46	.13	13.53	< .001	.63	.50-.81
Male (Reference)	---	---	---	---	---	---
Q1	-.75	.18	17.68	< .001	.47	.34-.67
Q2	-.38	.18	4.47	.03	.69	.49-.97
Q3	-.53	.18	8.49	< .01	.59	.41-.84
Q4 (Reference)	---	---	---	---	---	---
Constant	.78	.14	29.54	< .001	2.18	---
Volleyball*						
Female	-.61	.16	15.31	< .001	.54	.40-.74
Male (Reference)	---	---	---	---	---	---
Q1	-.81	.23	12.28	< .001	.44	.28-.70
Q2	-.83	.22	13.98	< .001	.44	.28-.68
Q3	-.64	.24	7.47	< .01	.53	.33-.83
Q4 (Reference)	---	---	---	---	---	---
Constant	.35	.19	3.24	.07	1.42	---

Notes. *SE*=Standard Error. *OR*=Odds ratio. 95% *CI*= 95% Confidence Interval. Q1= Quartile one. Q2= Quartile two. Q3= Quartile three. Q4= Quartile four.
* The regression model that includes the variables is significantly different than the constant only model $p < 0.05$.

Table 5

Sensitivity and Specificity Values for Binary Logistic Regression Models

Sport	Sensitivity (%)	Specificity (%)	Overall Correct (%)
All sports*	55.08	76.41	67.66
Basketball*	68.17	65.82	66.91
Cross Country	0.00	100.00	64.07
Field Hockey	100.00	0.00	59.78
Football*	0.00	100.00	86.23
Ice Hockey*	99.55	81.37	86.85
Rugby	28.53	75.56	53.59
Soccer*	64.36	58.42	61.64
Track & Field*	40.32	72.99	57.92
Volleyball*	94.86	13.53	66.09

Note. * The regression model that includes the variables is significantly different than the constant only model $p < 0.05$.

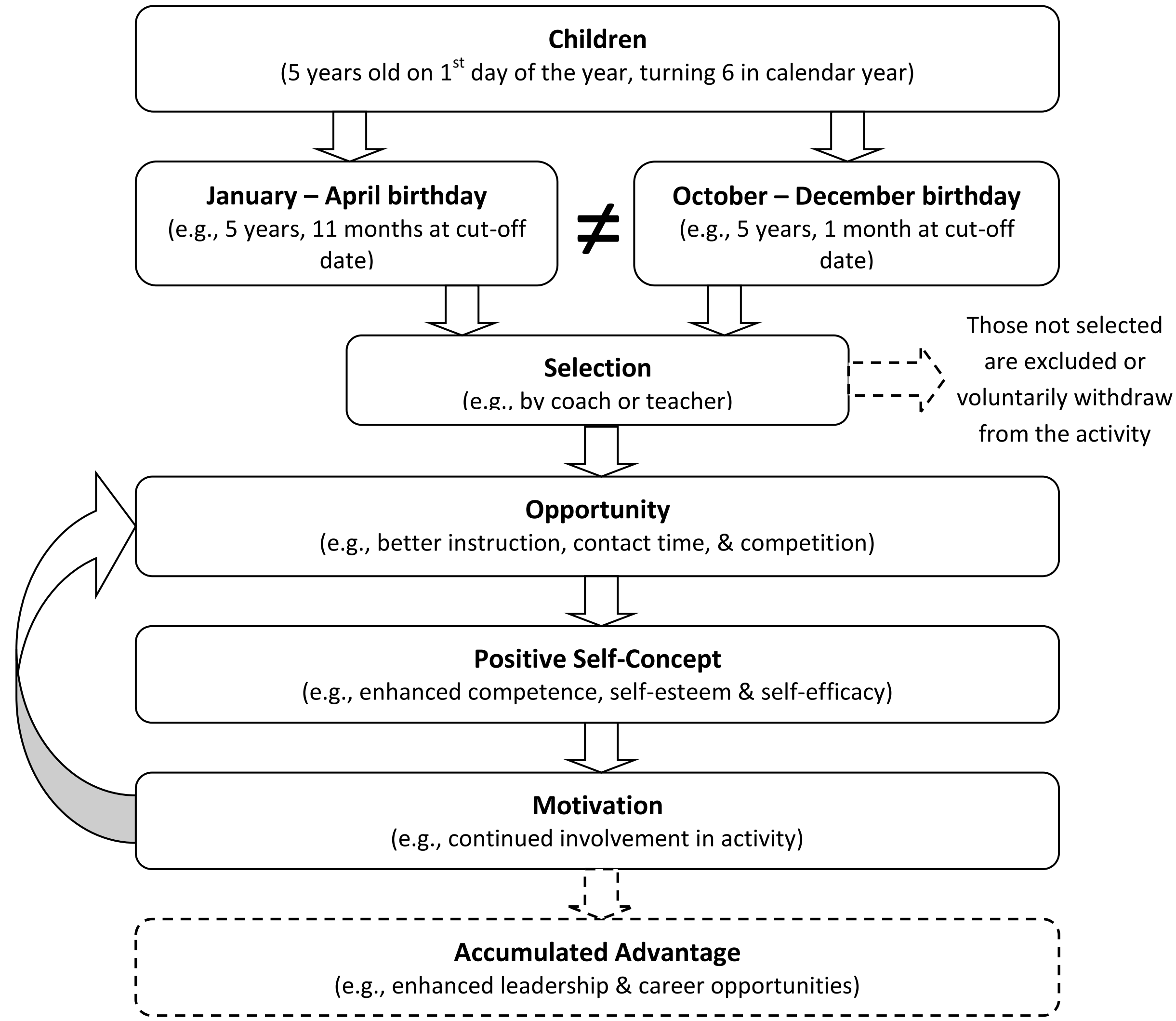

Figure 1. A model of the relative age effect (Dixon, Horton, & Weir, 2011).

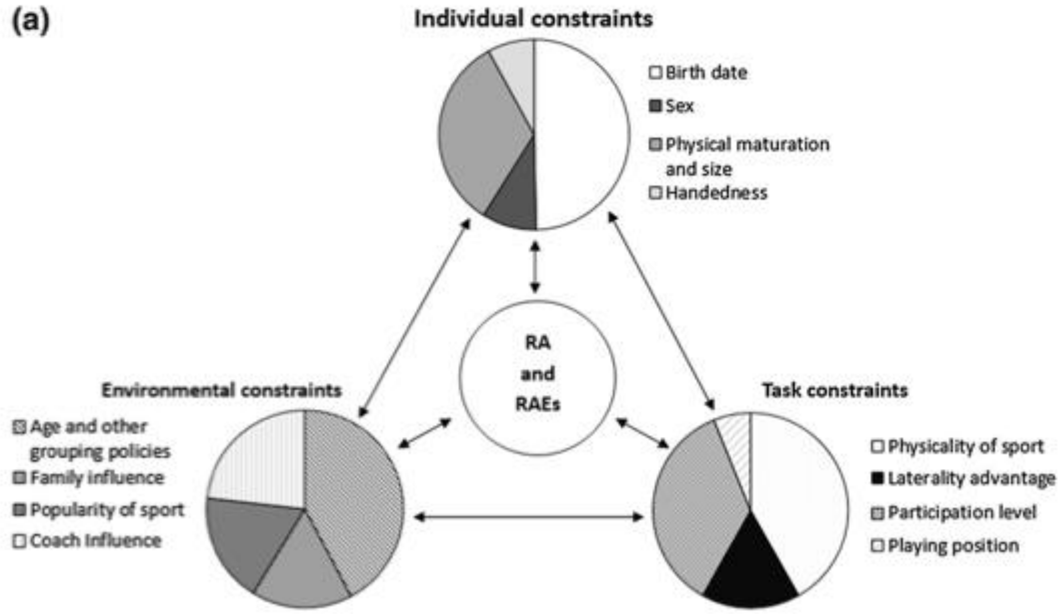

Figure 2a. Constraint profile for an interactive team sport (Wattie, Schorer, & Baker, 2015).

Note: This is an example of a constraint profile that could emerge for an interactive team sport such as ice hockey in Canada.

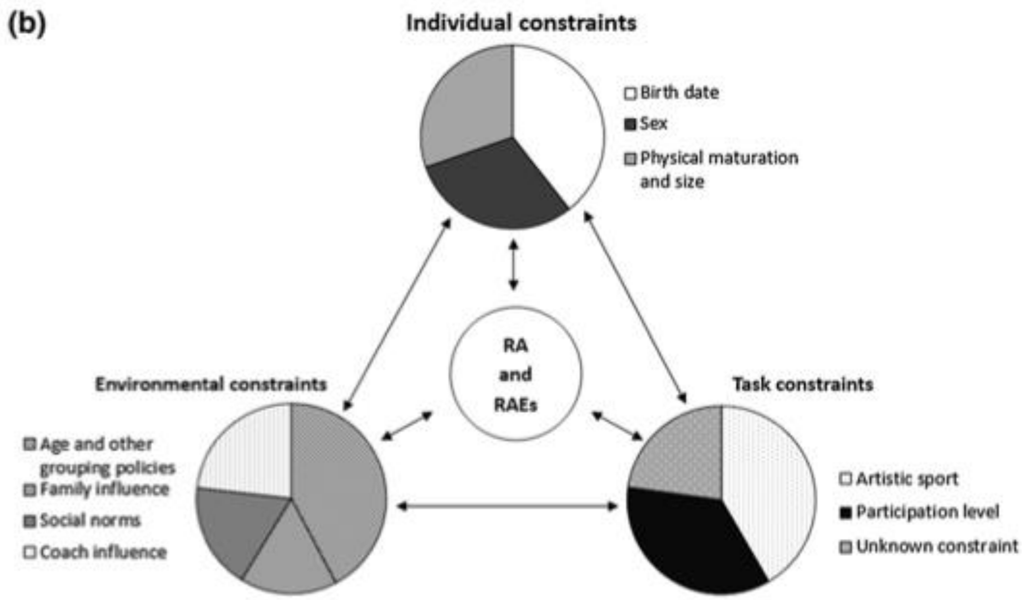

Figure 2b. Constraint profile for an artistic activity (Wattie, Schorer, & Baker, 2015).

Note: This is an example of a constraint profile may reflect the ecology of RAEs in an artistic sport such as female gymnastics.

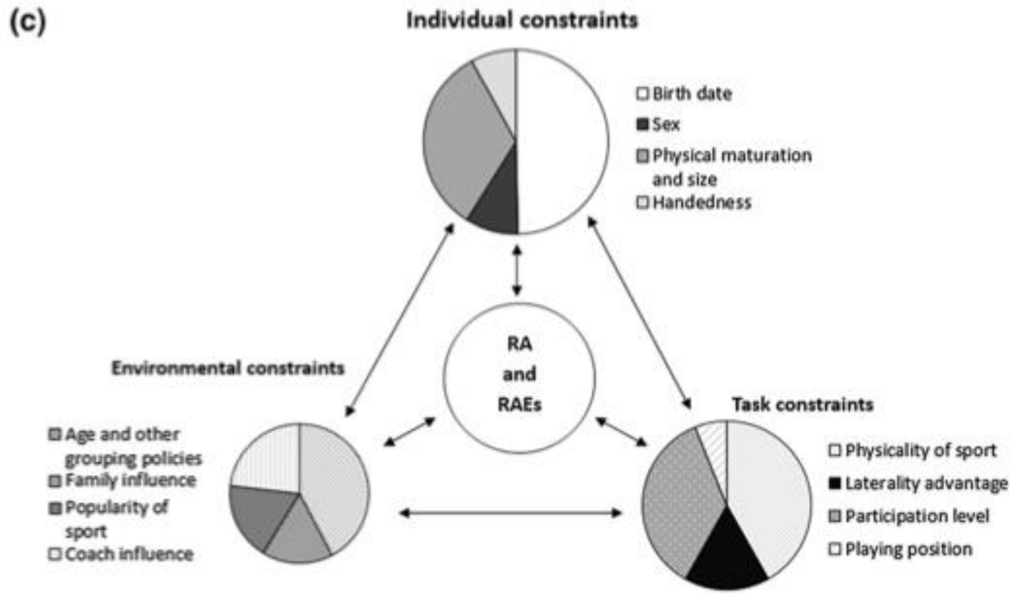

Figure 2c. Modification of Figure 2a and 2b (Wattie, Schorer, & Baker, 2015).

Note: This modification is used to display the relative contribution to each constraint type can also be depicted by the size of each 'pie' proportional to the other constraint pies. Also the size of the 'relative age and relative age effect' pie can be modified to demonstrate the given effect size of a relative age effect.

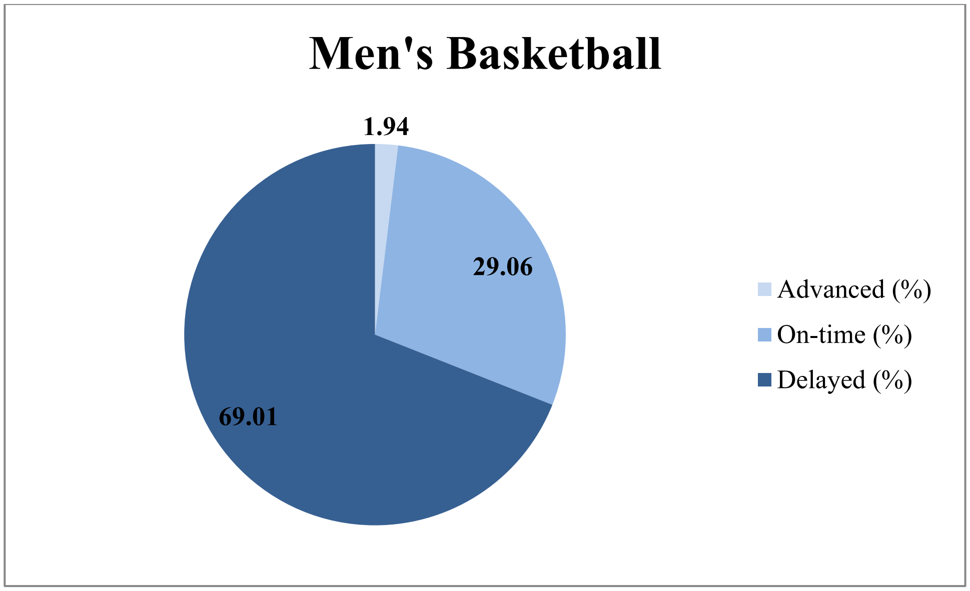

Figure 3. Percentage of on-time, delayed and advanced CIS male basketball players.

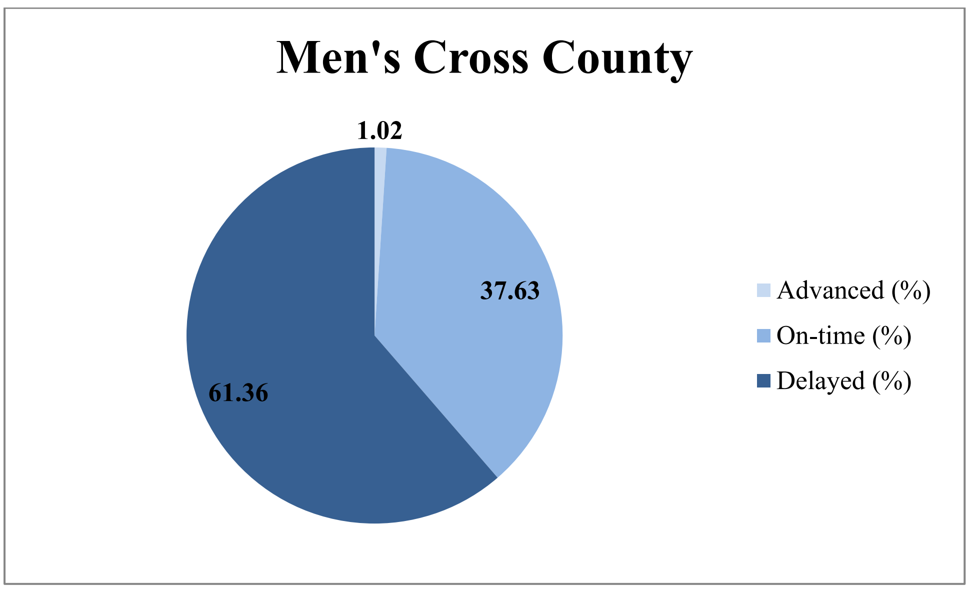

Figure 4. Percentage of on-time, delayed and advanced CIS male cross country athletes.

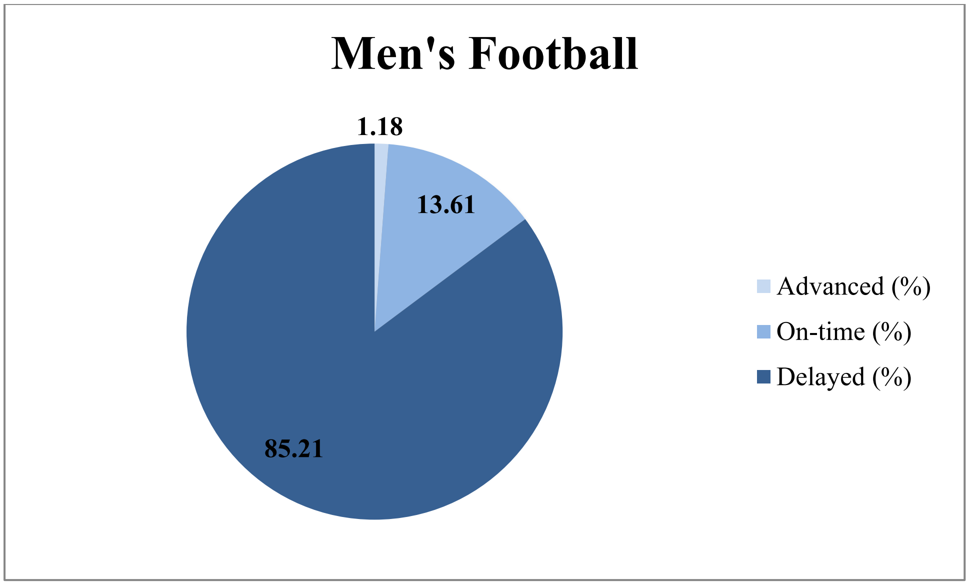

Figure 5. Percentage of on-time, delayed and advanced CIS male football players.

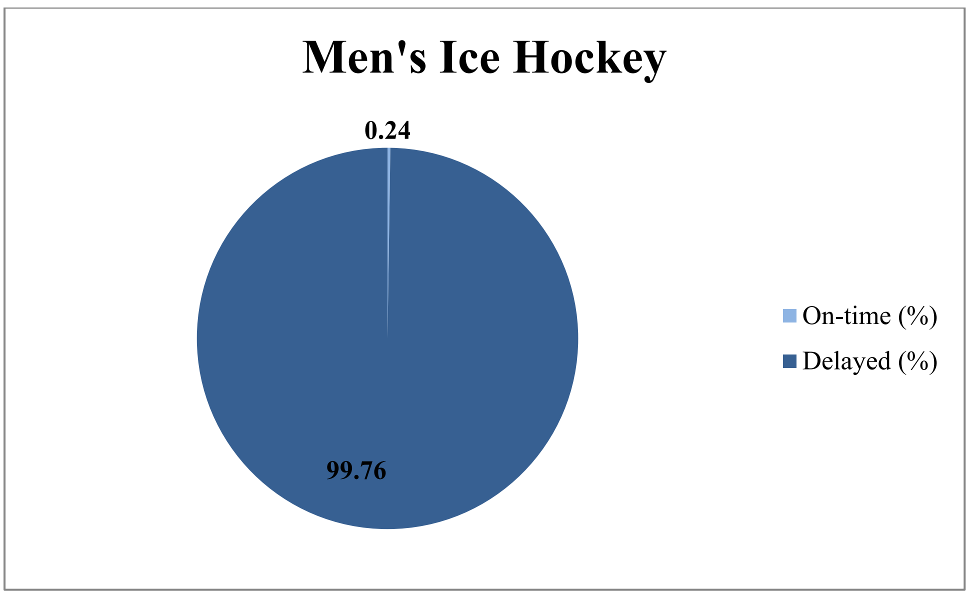

Figure 6. Percentage of on-time, delayed and advanced CIS male ice hockey players.

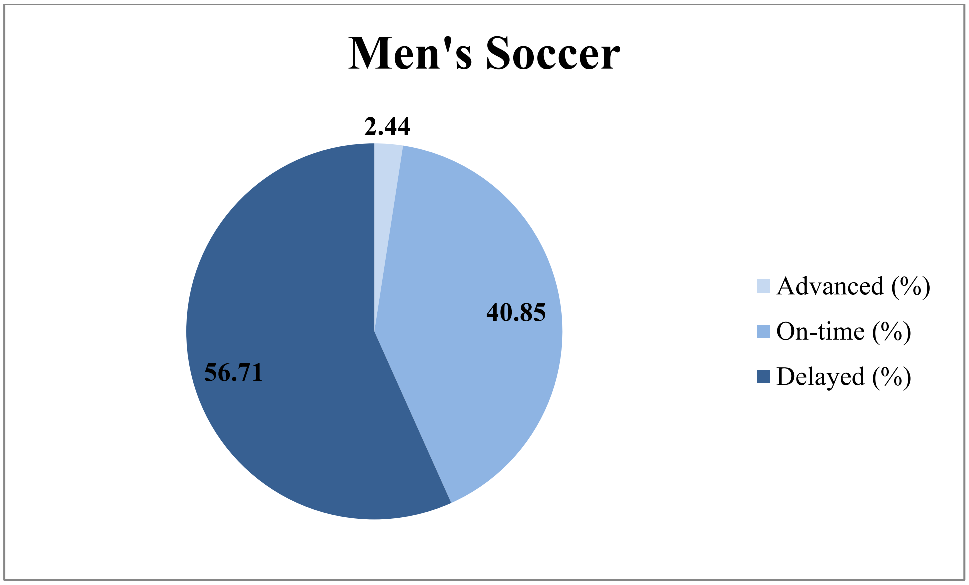

Figure 7. Percentage of on-time, delayed and advanced CIS male soccer players.

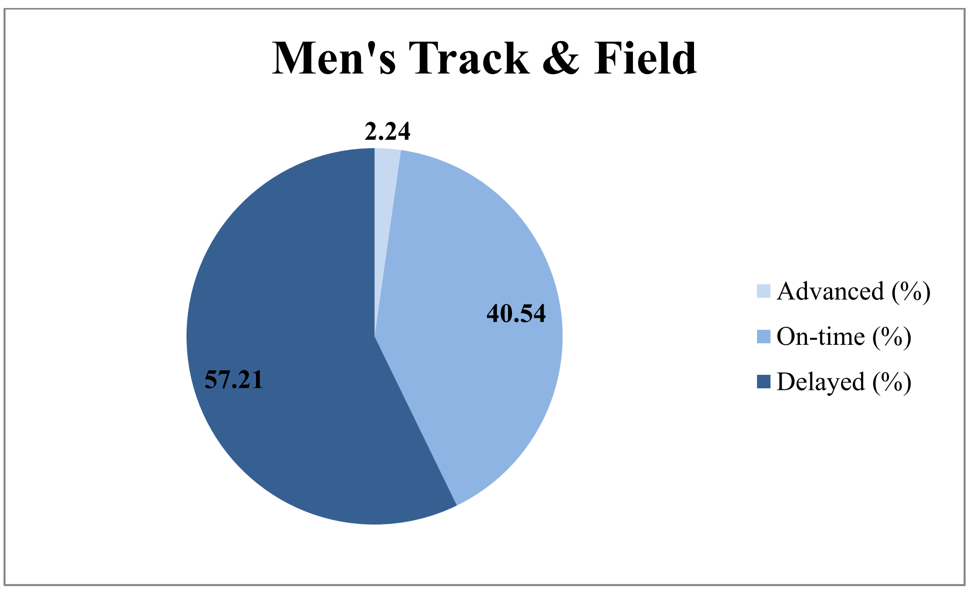

Figure 8. Percentage of on-time, delayed and advanced CIS male track and field athletes.

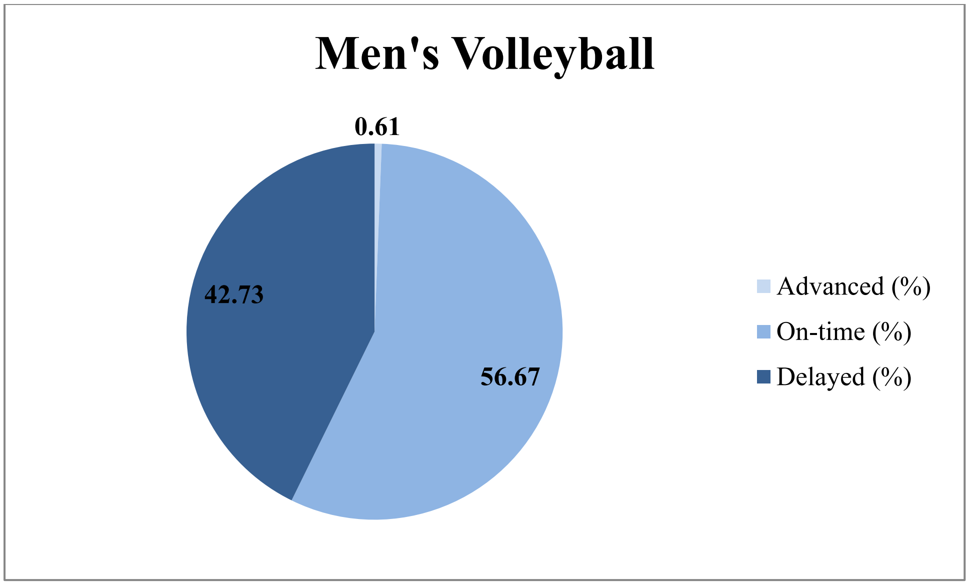

Figure 9. Percentage of on-time, delayed and advanced CIS male volleyball players.

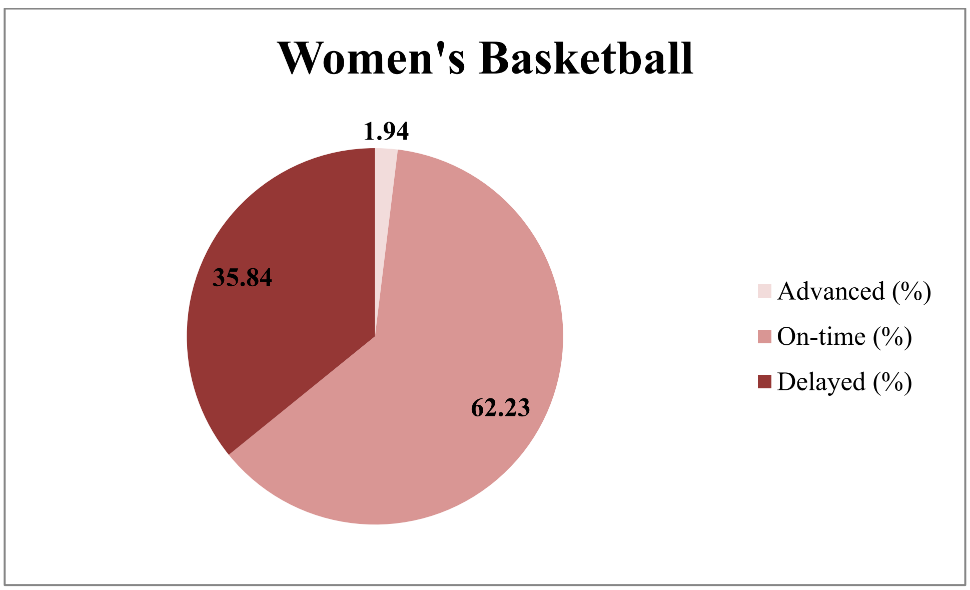

Figure 10. Percentage of on-time, delayed and advanced CIS female basketball players.

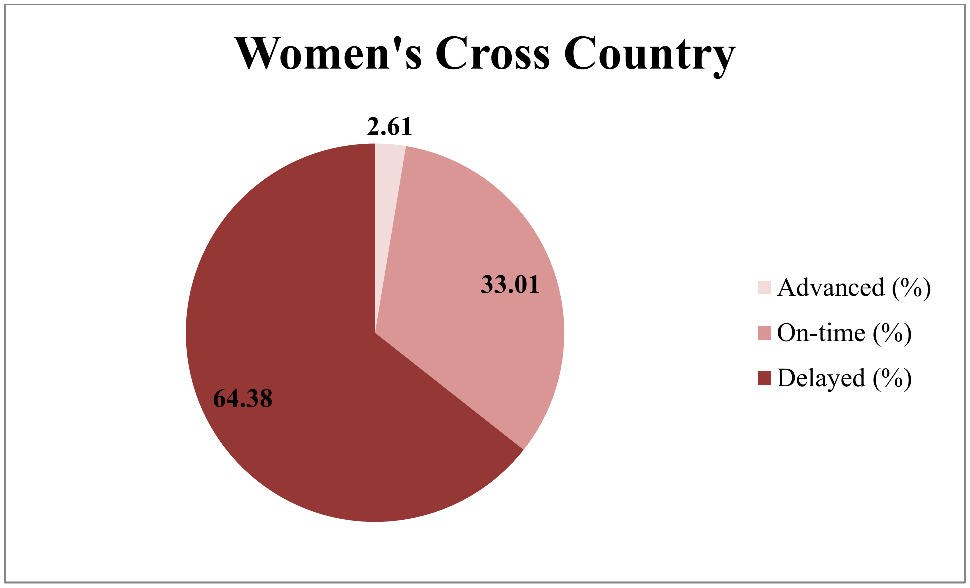

Figure 11. Percentage of on-time, delayed and advanced CIS female cross county athletes.

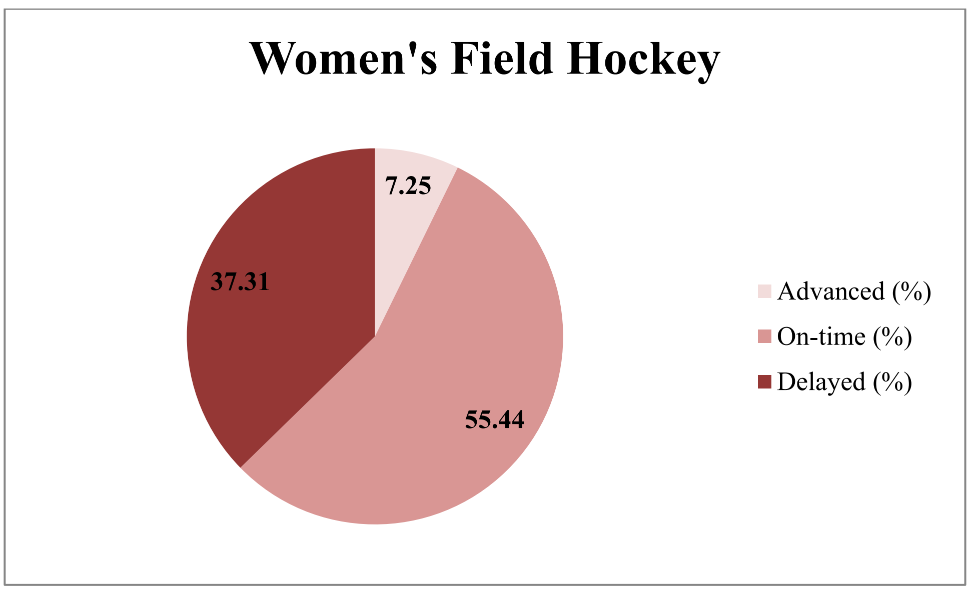

Figure 12. Percentage of on-time, delayed and advanced CIS female field hockey players.

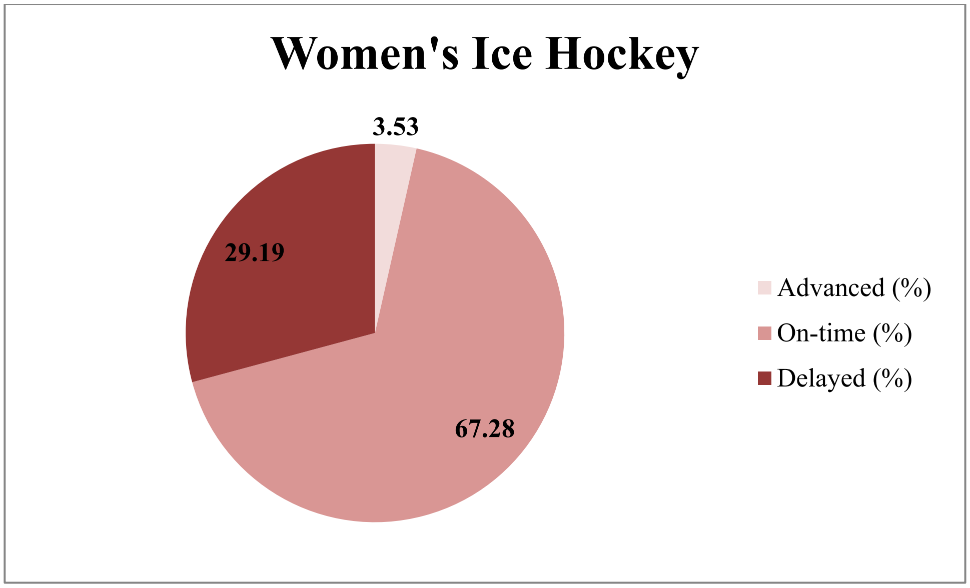

Figure 13. Percentage of on-time, delayed and advanced CIS female ice hockey players.

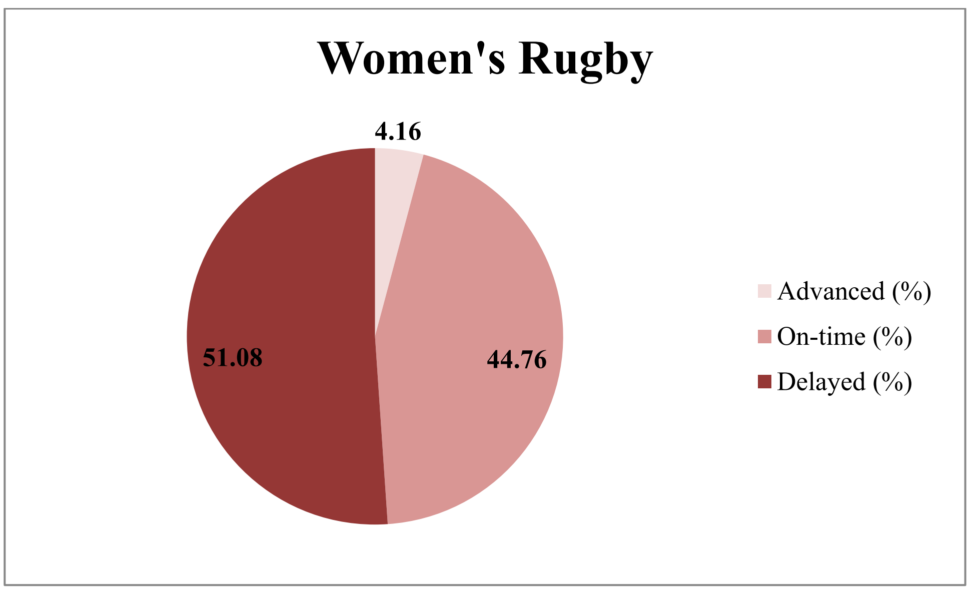

Figure 14. Percentage of on-time, delayed and advanced CIS female rugby players.

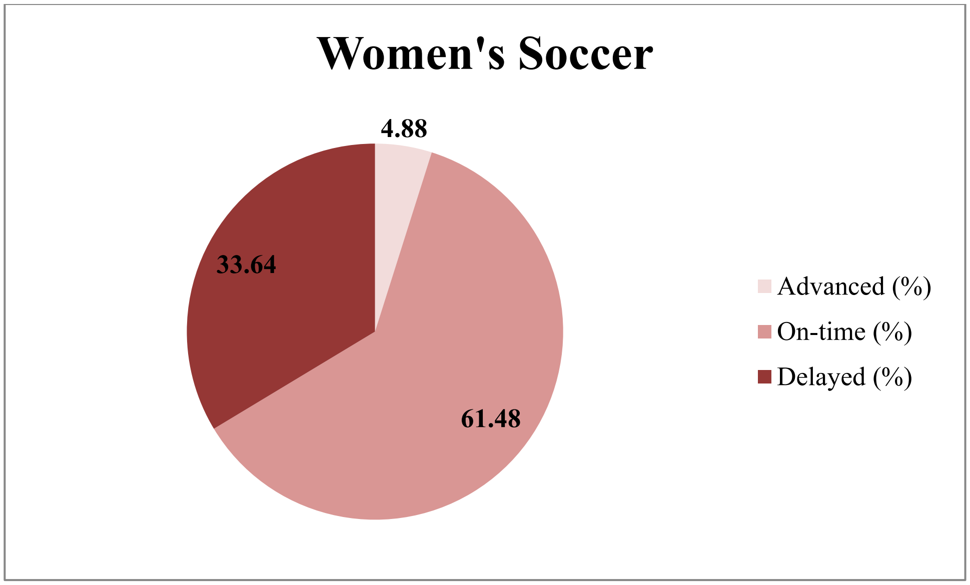

Figure 15. Percentage of on-time, delayed and advanced CIS female soccer players.

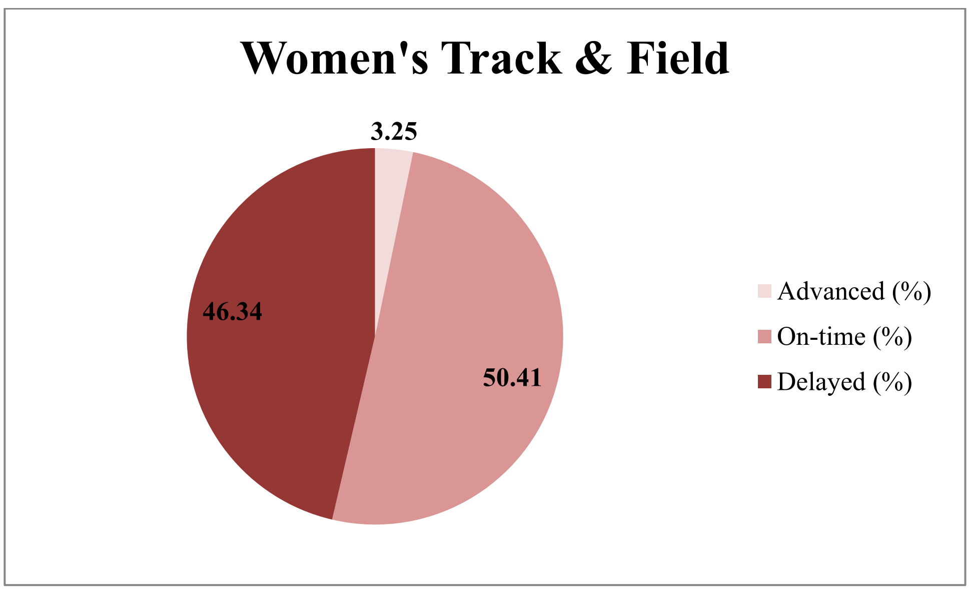

Figure 16. Percentage of on-time, delayed and advanced CIS female track and field athletes.

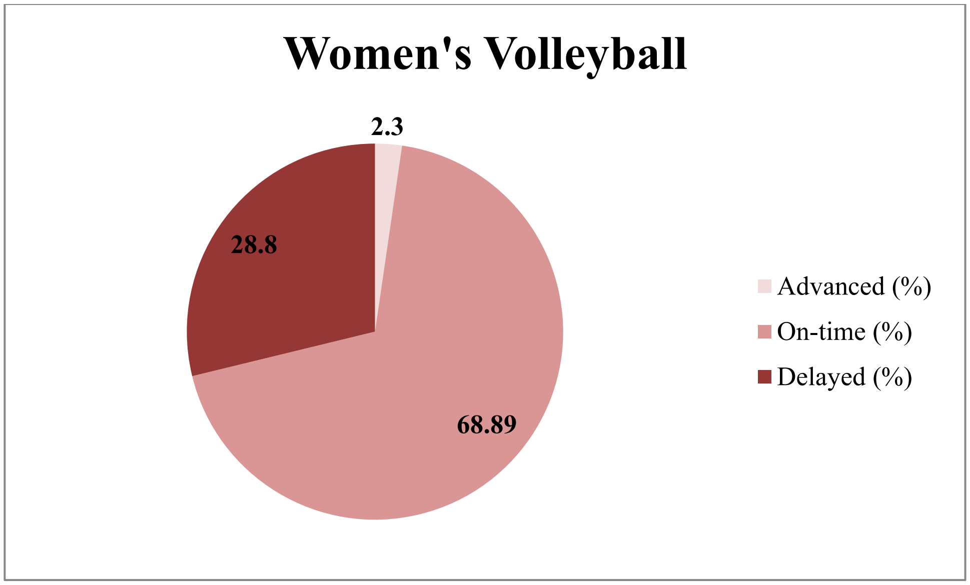

Figure 17. Percentage of on-time, delayed and advanced CIS female volleyball players.

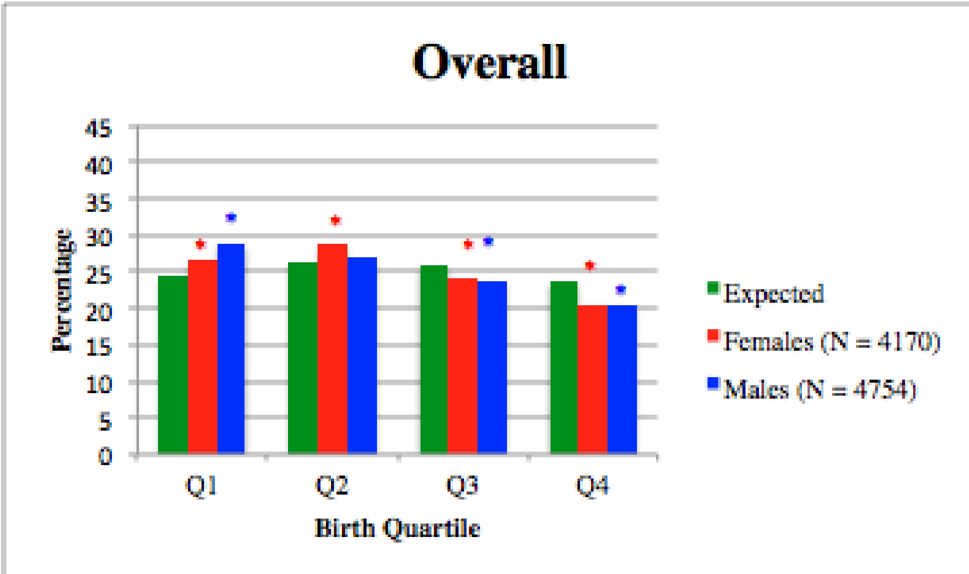

Figure 18. Overall birth distribution by quartile. Expected values derived from the Canada's Human Fertility Database for the years of 1989 through 1995. * = $p < 0.05$.

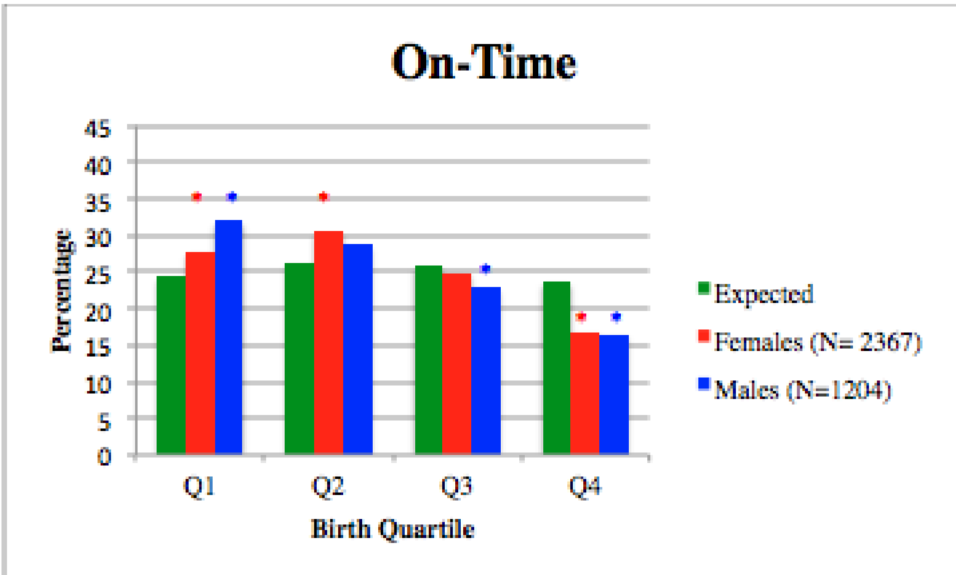

Figure 19. On-time birth distribution by quartile. Expected values derived from the Canada's Human Fertility Database for the years of 1989 through 1995. * = $p < 0.05$.

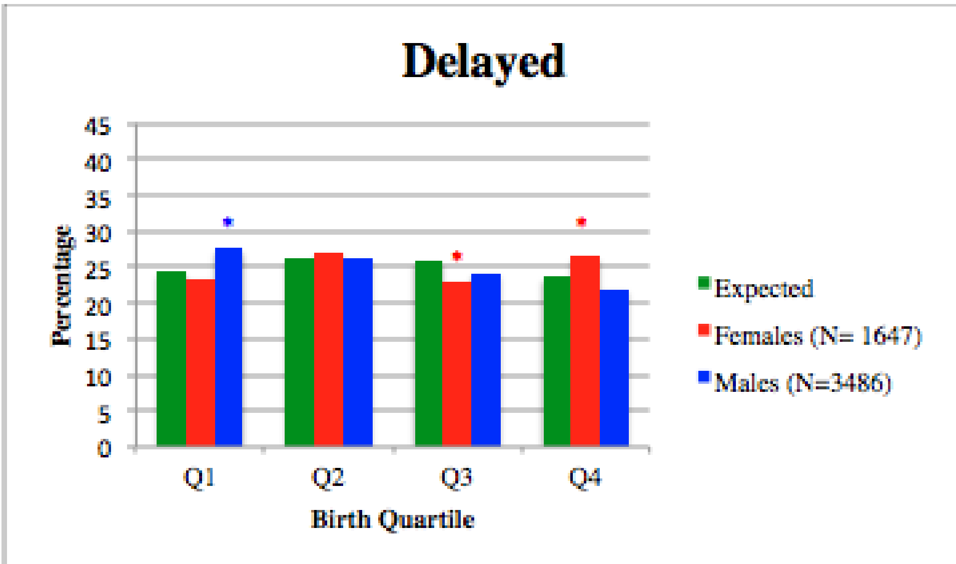

Figure 20. Delayed birth distribution by quartile. Expected values derived from the Canada's Human Fertility Database for the years of 1989 through 1995. * = $p < 0.05$.

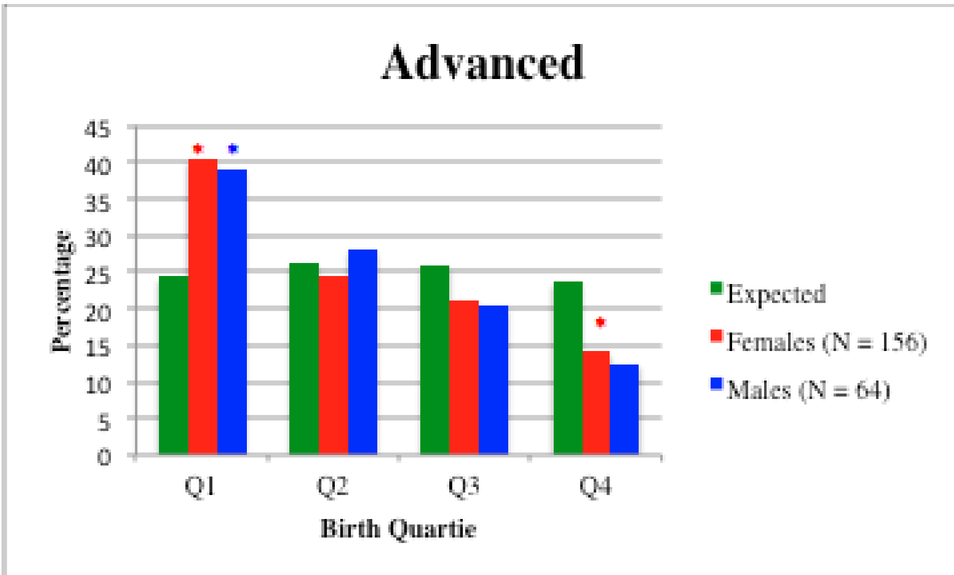

Figure 21. Advanced birth distribution by quartile. Expected values derived from the Canada's Human Fertility Database for the years of 1989 through 1995. * = $p < 0.05$.

Appendix: Copyright Permission

Wilma Vialle <wvialle@uow.edu.au> Mon, Jul 18, 2016 at 12:24 AM
To: Laura Chittle <chittlel@uwindsor.ca>

Dear Laura

As editor of the journal Talent Development and Excellence, published by IRATDE, I am happy to confirm that the arrangements outlined in your email below are fully approved by us.

All the very best

regards

Wilma

****

Professor Wilma Vialle

Chair of Academic Senate

Associate Dean International

Faculty of Social Sciences

Building 67 Room 306

University of Wollongong NSW 2522 Australia

T +61 2 4221 4434 | **F** +61 2 4221 4657

W socialsciences.uow.edu.au

On 18 Jul 2016, at 11:31 am, Laura Chittle <chittlel@uwindsor.ca> wrote:

Dr. Wilma Vialle,

I am completing a Master's thesis at the University of Windsor entitled "Examining the Relative Age Effect and Influence of Academic Timing on Participation in Canadian Interuniversity Sport." I would like your permission to include in my thesis the data I used in an article that I previously published in *Talent Development and Excellence*, Vol. 7, No. 1, 2015, 69-81, entitled: "Exploring the Relative Age Effect in Canadian Interuniversity Ice Hockey." The CIS ice hockey data that I used in this study represent a small (approximately 16.5%), yet important aspect of my thesis, but I will also be presenting other types of unrelated data. Please note that I have been diligent throughout my thesis document to cite the thoughts and ideas presented in the aforementioned manuscript, where appropriate.

My thesis will be deposited to the University of Windsor's online theses and dissertations repository (http://scholar.uwindsor.ca/etd/) and will be available in full-text on the internet for reference, study and / or copy.

Finally, I will also be granting Library and Archives Canada and ProQuest/UMI a non-exclusive license to reproduce, loan, distribute, or sell single copies of my thesis by any means and in any form or format. These rights will in no way restrict republication of the material in any other form by you or by others authorized by you.

In order to finalize my thesis and include the aforementioned data, I need to obtain permission from the copyright holder, which I believe is held by the International Research Association for Talent Development and Excellence. If this would be possible, it would be greatly appreciated.

Please confirm in writing that these arrangements meet with your approval.

Thank you in advance for your consideration of this request.

Sincerely,

Laura Chittle
BHK

LITERATURE REVIEW

The path to elitism in sport has become a popular focus among researchers. Baker and Horton (2004) proposed that skill acquisition and the development of expert performance in sport are influenced by both primary and secondary factors. While primary influences (i.e., genetic factors, training factors, and psychological factors) directly affect the attainment of elite performance, secondary influences (i.e., socio-cultural and contextual factors) have an indirect role and are often overlooked. An individual's birthdate or 'relative age' is an important contextual variable that can impact many primary and secondary factors. For example, an individual's relative age may influence his or her access to quality training (primary factor) and access to knowledgeable coaching (secondary factor).

Relative Age Effect

A common practice within sport and educational domains is to group individuals based on their chronological age (Baker, Schorer, & Cobley, 2010; Musch & Grondin, 2001; Vincent & Glamser, 2006) to help promote equal competition, age appropriate instruction, and ensure safety (Barrow & McGee, 1971; Musch & Grondin, 2001). While well-intended, such grouping practices can often lead to differences in ages among individuals within these groups. The term 'relative age' describes the variation in age among individuals grouped together based on a pre-established cut-off date (Barnsley & Thompson, 1988; Barnsley, Thompson, & Barnsley, 1985). For example, when using a January 1st cut-off date, the relatively oldest children commencing kindergarten at five years old can, in some cases, be nearly 20% older than their relatively younger peers (Dixon, Horton, & Weir, 2011). The consequence of such age disparities often results in the formation of ‘relative age effects’ (RAEs; Barnsley et al., 1985). The RAE explains the relative (dis)advantages experienced by individuals grouped into the same age-cohort (Barnsley et al., 1985). Those who are relatively older often experience developmental and selection advantages, while those who are relatively younger are often disadvantaged in a variety of disciplines (e.g., academics and athletics).

Relative Age Effects in Education

Differences in attainment outcomes due to relative age were first witnessed in the education system (Armstrong, 1966; Freyman, 1965). Since these initial investigations, subsequent studies have demonstrated that those who are relatively older tend to have higher achievement scores across various subjects (Bedard & Dhuey, 2006; Cobley, Baker, Wattie, & McKenna, 2009a; Smith, 2009), are more likely to hold leadership positions in their schools, such as team captain or club president (Dhuey & Lipscomb, 2008), and are more often selected for ‘gifted’ programs (Cobley et al., 2009a). Conversely, those who are relatively younger have slightly higher risks of suicide (Thompson, Barnsley, & Dyck, 1999), are less likely to attend university (Bedard & Dhuey, 2006), more likely to be identified as requiring learning support as well as have lower school attendance rates (Cobley et al., 2009a), and are more likely to be misdiagnosed with Attention Deficit Hyperactivity Disorder (Elder, 2010; Evans, Morrill, & Parente, 2010). While the scope of this literature review is to only highlight some of the RAE findings in education, it is evident “… that children who experience the negative effects of a young relative age on school entry will experience both short- and long-term disadvantages at a higher rate than their age-grouped older classmates” (Thompson et al., 1999, p. 83). The consequences associated with relative age are not limited to education;

there are important parallels that exist in a sporting context as well (Musch & Grondin, 2001). Such similarities include competing for a position on a sporting team compared to a spot in a gifted program.

Relative Age Effects in Sport

Within relative age research, sport has become a popular focus (for a comprehensive meta-analytic review of this literature please see Cobley, Baker, Wattie, & McKenna, 2009b). Since Cobley et al.'s (2009b) meta-analysis was completed, there has been a considerable amount of research examining other sports, leading to a more comprehensive, yet nuanced understanding of the RAE phenomenon. A RAE occurs in sport when there are a greater percentage of athletes born in the months immediately after a cut-off date compared to the later months, displaying a linear negative relationship between participation rates and month of birth. An unfortunate, yet common consequence associated with RAEs in sport is relatively younger athletes dropping out of sport to pursue other types of activities that are potentially more fulfilling (e.g., Barnsley & Thompson, 1988; Delorme, Boiché, & Raspaud, 2010a; Delorme, Boiché, & Raspaud, 2010b; Delorme, Chalabaev, & Raspaud, 2011; Helsen, Starkes, & Van Winckel, 1998; Lemez, Baker, Horton, Wattie, & Weir, 2014).

When conducting RAE studies, it is common for researchers to categorize athletes into birth quartiles based on the annual cut-off date for a particular sport. For example, Hockey Canada uses December 31st (Hockey Canada, 2013) as its cut-off date. In this particular case, quartile one (Q1) would consist of athletes born in the months of January, February, and March, quartile two (Q2) contains athletes born in April, May, and June, quartile three (Q3) is comprised of athletes born in July, August, and September, and quartile four (Q4) is composed of athletes born in October, November, and December.

Cobley et al.'s (2009b) meta-analysis contained 14 sports that were examined for RAEs. The vast majority of these studies were focused on ice hockey (32.8%), soccer (30%), and baseball (13%). While this meta-analysis is comprehensive, other sports have also been investigated in recent years, including, but not limited to, handball, ski-jumping, and alpine skiing.

Causes of RAEs

The RAE is a multifaceted phenomenon with numerous contributing factors and antecedents. Musch and Grondin (2001) presented four mechanisms that contribute to the RAE: competition, physical development, psychological factors, and experience. For a RAE to develop, there must be competition between participants to make a particular team, typically resulting from a limited number of positions available and a large number of individuals vying for one of these positions. Particularly within travel sports, where there is intense competition among athletes to make the team, relative age differences among individuals are enhanced. However, at house league or recreational levels of sport, there is no element of coach selection involved and thus athletes do not have to compete to make the team resulting often in no RAEs at this competitive level. Differences in physical size and psychological maturity between those who are relatively older and younger can further perpetuate RAEs (Musch & Grondin, 2001). For example, Barnsley et al. (1985) noted that those who are relatively older are often bigger, stronger, and better coordinated than those who are relatively younger and, consequently, have more success in sports. Alternatively, those who are relatively younger often feel frustrated and have a more negative sporting experience, ultimately dropping out of sport to pursue other activities. Similarly, Helsen et al. (1998) suggested that relatively older soccer players are more likely to be seen as talented by coaches because of their increased physical size, which results in exposure to better coaches and increased likelihood to participate on elite level teams. Finally, the mechanism of experience is best illustrated with an example:

> Among 10-year-old children, an 11-month difference in age represents, of course, considerable advantages in terms of height, weight, strength, and cognitive development. However, beyond these mere facts, this age difference represents almost 10% of total life experience. Maybe more importantly, this difference represents an extra year of experience in a given sport itself, which means much more. This training effect is likely to enhance chances of participating more actively in games during the season. (Musch & Grondin, 2001, p. 159)

While there are likely numerous mechanisms responsible for influencing RAEs, Dixon et al. (2011) present a simplified model (see Figure 1) detailing how RAEs are caused. In summary, these authors suggest that RAEs are typically present in developmental systems where individuals are selected based on their ability, and once selected, they are placed into different categories (e.g., gifted or competitive) that offer differing opportunities for instruction, contact time, and competition.

Aside from the aforementioned factors and mechanisms, Baker et al. (2010) proposed that RAEs are moderated by a variety of factors including: intensity of competition, sex, socio-economic status, and playing position. Within the current study, information pertaining to moderators is limited (i.e., only sex and intensity of competition are known) and, therefore, further information detailing the impact of such moderators is beyond the scope of this thesis. More information about the various mechanisms and cause of the RAE can be found in Baker et al. (2010) and Dixon et al. (2011).

Over the years, there have been numerous attempts to establish a theoretical framework encompassing the previously mentioned mechanisms and moderators that cause RAEs. The first framework was presented by Baker, Schorer, Cobley, Schimmer, and Wattie (2009) using Bronfenbrenner's (1977) Ecological Systems Theory. Shortly thereafter, Hancock, Adler, and Côté (2013) attempted to explain RAEs using Matthew, Pygmalion, and Galatea effects. However, these frameworks have some limitations, not the least of which are that RAEs are far too complex to be sufficiently explained by these theories alone, and that they are not domain-specific in their application (Wattie, Schorer, & Baker, 2015).

To help overcome these limitations, Wattie et al. (2015) created a theoretical model to account for the broad range of mechanisms that may influence the presence or absence of RAEs. Using Newell's (1986) framework[3], these researchers highlighted three interacting constraints that can impact RAE profiles in various situations: individual constraints (e.g., birth date, sex, physical maturation and size, handedness), task constraints (e.g., physicality of sport, laterality advantage, participation level, playing

[3] Newell (1986) proposed three interacting constraints (i.e., organismic constraints, task constraints, and environment constraints) that are responsible for optimizing coordination and control for an activity. Wattie et al. (2015) refers to organismic constraints as individual constraints because they describe factors that relate to individual human qualities.

position), and environmental constraints (e.g., age and other grouping policies, family influence, popularity of sport, coach influence). For example, considering an individual constraint such as sex, researchers have suggested that RAEs are not consistently observed in female sport. While some studies on female athletes have shown significant RAEs (e.g., Delorme & Raspaud, 2009; Dixon, Liburdi, Horton, & Weir, 2013; Smith & Weir, 2013; Weir, Smith, Paterson, & Horton, 2010), others have found no such effect (e.g., Delorme, Boiché, & Raspaud, 2009; Vincent & Glamser, 2006; Wattie, Baker, Cobley, & Montelpare, 2007). Furthermore, compared to the male RAE profile, the female pattern has been found to be non-linear, with many studies exhibiting a peak in the number of athletes in Q2 (e.g., Baker, Schorer, Cobley, Bräutigam, & Büsch, 2009; Delorme et al., 2010a; Weir et al., 2010). The influence of a task constraint, such as participation level, can be seen in Barnsley and Thompson's (1988) analysis of minor league ice hockey players when they noticed reversals in the RAE in the lowest tiers of minor league ice hockey. This reversal in the RAE is characterized by a greater proportion of relatively younger athletes participating compared to relatively older athletes, indicating a positive linear relationship. To illustrate the importance of environmental constraints, such as the importance of age and other grouping polices on RAEs, we do not see RAEs in football (e.g., Daniel & Janssen, 1987; MacDonald, Cheung, Côté, & Abernethy, 2009). This may stem from youth football organizations utilizing age and weight grouping polices, rather than simply age alone.

In sum, Wattie et al.'s (2015) developmental model is effective in displaying how different circumstances can result in unique constraint profiles, and how the contribution of each constraint type may differ depending on the situation or system. For examples of three hypothetical constraint profiles please see Figures 2a, 2b, and 2c. While this model provides a great deal of information regarding the various constraints that may influence RAEs in different situations, a deeper explanation of the model is beyond the scope of this literature review. For more information about this theoretical framework please refer to Wattie et al. (2015).

Canadian Interuniversity Sport

Canadian Interuniversity Sport (CIS) was established in June 2001 and is the primary governing body for varsity athletics within degree-granting educational institutions in Canada[4]. Prior to this time, intercollegiate athletics in Canada were governed by the Canadian Interuniversity Athletic Union (CIAU), which was initiated in 1906 and later rebranded to CIS. At present, there are 55 member institutions, 12 different sports, and more than 11, 000 student-athletes who participate. Currently, there are four regional associations where student-athletes compete: Canada West Universities Athletic Association, Ontario University Athletics, Réseau du sport étudiant du Québec, and Atlantic University Sport. Students-athletes are eligible to participate for five years with no age restrictions. However, within the sport of football these five years of eligibility must be used within an eight (Quebec high school graduates) or seven (non-Quebec high school graduates) year period following the expected date of one's high school graduation (Canadian Interuniversity Sport [CIS], n.d.).

---

[4] It is important to note that varsity athletes compete at colleges in Canada as well. However, Canadian colleges have their own separate governing body for athletics known as the Canadian Collegiate Athletic Association (CCAA), which operates separate from CIS.

Basketball

When considering professional basketball leagues, RAEs have been demonstrated to exist among male basketball players in Germany (Schorer, Neumann, Cobley, Tietjens, & Baker, 2011) and Japan (Nakata & Sakkamoto, 2011), but not among top female Japanese basketball players (Nakata & Sakamoto, 2012). However, at arguably the highest caliber of basketball, researchers have failed to find RAEs among players participating in the 1984-1985 (Daniel & Janssen, 1987), 2002-2003 (Côté, MacDonald, Baker, & Abernethy, 2006), and 2004-2005 (Esteva & Drobnic, 2006) National Basketball Association (NBA) seasons. It is possible that these inconsistent findings may be related to the 'street' or 'pick-up' nature of basketball, whereby individuals may participate in this sport in an unorganized manner (i.e., with no age categorizations) with friends and/or family members while growing and helping to develop skills.

Subsequent studies of male (Lidor, Côté, Arnon, Zeev, & Cohen-Maoz, 2010) and female (Lidor, Arnon, Maayan, Gershon, & Côté, 2014) Israeli-born Division I basketball players found no RAE. In these cases, Division I represents the highest level of competitive play and national teams are often generated from players participating at this level. Collectively, these authors suggested that the lack of a RAE could be explained by the small number of children in Israel interested in participating in sports. As a result, there is less competition between athletes to make these teams and thus, the selection process of coaches may be less stringent (Lidor et al., 2010; Lidor et al., 2014).

At the youth level, Delorme and Raspaud (2009) examined the birthdate distribution of males and females (7-18 years of age) participating in the French

Basketball Federation (FFBB). Their results indicated a significant RAE for both males and females in all age divisions, with the largest differences being witnessed among 13-14 year olds, and the strongest effects occurring in the female categories. Subsequently, Delorme et al. (2011) displayed evidence that more relatively younger athletes dropped out of the FFBB than relatively older athletes for the 9-10, 11-12, 13-14, and first year of the 15-17 year old age categories.

In line with previous studies, RAEs were also witnessed in the Basketball World Championships for the Under (U)-17 and U-19 age categories but did not exist in the U-21 category for male and female players (García, Aguilar, Romero, Lastra, & Oliveira, 2014). Since the vast majority of the investigations on basketball have relied on international samples that may have different sport development systems, it is difficult to predict how RAEs may influence developmental basketball in North America.

Cross country

To the best of my knowledge no study has examined the influence of relative age on participation within the sport of cross country.

Curling

Raschner, Müller, and Hildebrandt (2012) provide the only known insight into the state of RAEs within the sport of curling. These researchers examined 15 different sports occurring in the first winter Youth Olympic Games held in 2012 and categorized them into three groups: strength-related, endurance-related, and technique-related. Curling, along with freestyle skiing (halfpipe), figure skating, snowboard, and ski jumping, were considered to be technique-related sports. Overall, a significant RAE was found for technique-related sports, with older athletes approximately two times more likely to participate. However, since a number of sports were grouped together in this analysis, it is difficult to determine the extent of the RAE in curling alone.

Field Hockey

While there is limited knowledge on the state of RAEs within field hockey, research on students selected to represent a comprehensive school in England provided evidence of a skewed birthdate distribution. Specifically, female field hockey players were more than three times more likely to be born in the first third of the school year compared to the last third (Wilson, 1999).

Football

Daniel and Janssen (1987) provided the first insight into the state of RAEs within professional football. When examining Canadian Football League players participating in the 1984-1985 season, no RAE was witnessed. Similarly, within the same National Football League (NFL) season, there were slightly more athletes born in the early months of the year, although these results were not statistically significant (Daniel & Janssen, 1987). Since this initial study, researchers have found no evidence of a RAE in members of the American Football Hall of Fame (Stanaway & Hines, 1995), players competing in the 2004 NFL season (MacDonald et al., 2009), and among Japanese male football players competing in the top Japanese league (Nakata & Sakamoto, 2011).

Glamser and Marciani (1992) analyzed the birthdates of two National Collegiate Athletic Association (NCAA) Division I football teams and found a nearly equal distribution of birthdates across the year. Given that the vast majority of NFL football players would have participated at this level prior to being drafted into the NFL, it seems logical that a RAE would not exist in the professional ranks. It is possible that RAEs do not exist within this physical sport because some youth football leagues (e.g., Pop Warner football in the United States) classify athletes by age and weight (Pop Warner Little Scholars Incorporated, n.d.), which may help to minimize developmental differences between athletes and reduce relative age advantages that may accumulate over time.

Ice Hockey

Ice hockey was one of the first sports to be examined for RAEs (Grondin, Deshaies, & Nault, 1984). Grondin et al. (1984) revealed an unequal birth pattern for male Canadian ice-hockey players at the recreational, competitive, and senior professional levels. Similarly, Barnsley et al. (1985) provided strong evidence of a traditional RAE in the National Hockey League (NHL), Western Hockey League (WHL), and Ontario Hockey League (OHL) in the 1982-1983 season. Similarly, Daniel and Janssen (1987) witnessed a significant RAE in the 1985-1986 NHL season, but not in four NHL seasons occurring in the 1960s and 1970s. As noted previously, Cobley et al.'s. (2009b) meta-analysis revealed that nearly one third of all RAE studies to that point in time had focused on ice hockey. More recently, researchers have demonstrated RAEs to still exist across a number of NHL seasons (e.g., Addona & Yates, 2010; Barnsley et al., 1985; Boucher & Mutimer, 1994; Côté, et al., 2006; Montelpare, Scott, & Pelino, 2000; Nolan & Howell, 2010; Wattie, Baker, et al., 2007). Addona and Yates (2010) conducted a retrospective analysis of Canadian born NHL players and proposed that RAEs began for players born after 1950. It was hypothesized that this was a result of Canada changing its ice hockey developmental programs in order to combat the strong emergence of the Soviet Union into international ice hockey.

Traditional RAEs have also been found to exist within other elite ice hockey divisions, including the Canadian Hockey League[5] (e.g., Montelpare et al., 2000; Nolan & Howell, 2010), within four countries participating in the International Ice Hockey Federation's World Junior Hockey Championships from 2000-2009 (Bruner, Macdonald, Pickett, & Côté, 2011), NHL draftees from 2000-2005 (Baker & Logan, 2007), and French elite male ice hockey players (Delorme et al., 2009).

Perhaps of greater concern than the RAE impacting elite ice hockey is the influence it can have on youth ice hockey participation. In fact, numerous studies have established RAEs to exist in a number of youth age divisions, across many competitive levels, and throughout several different Canadian provinces (e.g., Barnsley & Thompson, 1988; Boucher & Mutimer, 1994; Monteplare et al., 2000; Hancock, Ste-Marie, &Young, 2013; Turnnidge, Hancock, & Côté, 2014). Moreover, when considering only one province, Turnnidge et al. (2014) performed a comprehensive analysis of 146,424 competitive and recreational athletes registered with the Ontario Hockey Federation between 2004 and 2010. The results of this study indicated a significant RAE. However, the RAE pattern varied slightly from the traditional linear trend, as the largest number of athletes were born in Q2 (27.76%), and fewer athletes born in Q1 (24.92%) than would

[5] The Canadian Hockey League (CHL) is comprised of the OHL, WHL, and the Quebec Major Junior Hockey League (QMJHL).

normally be expected. It is possible that the RAE trend within this sample differed from previous studies because the researchers did not perform separate analyses on the athletes competing competitively and recreationally. Including athletes participating recreationally may have lessened the relative age advantage experienced by those born in Q1. While RAEs tend to exist in competitive youth ice hockey, particularly when there is an element of coach selection or a tryout process, when selection processes are absent (e.g., house league ice hockey), RAEs are generally not found (e.g., Chittle, Horton, Weir, & Dixon, 2015; Hancock, Ste-Marie, et al., 2013; Montelpare et al., 2000). The differences in RAE patterns across the various levels of youth ice hockey highlights the important role that competition level has on the formation of RAEs.

It is important to note that, while the vast majority of the literature has supported the notion that those who are relatively younger are consistently disadvantaged, there are a small number of studies that supports the opposite. For example, Gibbs, Jarvis, and Dufur (2011) indicate that relatively younger NHL players are more likely to be selected for All-Star and Olympic teams, and enjoy longer career durations. Similarly, Baker and Logan (2007) demonstrate that relatively younger draftees are more likely selected in the earlier rounds of the NHL draft. Thus, it may be plausible that relatively younger athletes who 'survive' in a system that disadvantages them actually become better athletes in the long term (Schorer, Cobley, Büsch, Bräutigam & Baker, 2009). At the youth level, Wattie, Cobley, et al. (2007) found relatively older ice hockey players were more prone to injuries than their relatively younger peers, and that this risk increases with more competitive levels of play. This is likely a consequence of relatively older athletes participating more frequently and at more elite levels (potentially due to the greater physical maturity associated with being older), resulting in an increased exposure to injuries.

Within women's ice hockey, the trends are more equivocal and researchers continue to draw conflicting conclusions. One study found no presence of the RAE among Canadian Women's National Championship ice hockey players (Wattie, Baker, et al., 2007), while a second found a larger percentage of athletes who represented Canada nationally and internationally were born in the first half of the year (Weir et al., 2010). Furthermore, the RAE has also been found to exist within developmental girls ice hockey as well (e.g., Hancock, Seal, Young, Weir, & Ste-Marie, 2013; Smith & Weir, 2013). A number of studies have found female ice hockey players to display a non-linear RAE pattern, characterized by an overrepresentation in the number of athletes born in Q2 (e.g., Hancock, Seal, et al., 2013; Smith & Weir, 2013; Weir et al., 2010). This unique feature has been seen in other studies conducted on female soccer players (Baker, Schorer, Cobley, Bräutigam, et al., 2009; Delorme et al., 2010a). While the vast majority of studies focusing on female ice hockey players have examined North American athletes, Stenling and Holmström (2014) provided evidence of RAEs among Swedish women's elite, junior elite, and youth ice hockey players. Contrary to Weir et al. (2010), Stenling and Holmström (2014) displayed more traditional RAE patterns among their entire sample of Swedish elite players, as well as their sample of youth players (ages 5-20).

Rugby

A comprehensive analysis of the United Kingdom Rugby League revealed an uneven birthdate distribution for male players in different age groups ranging from U-7 to senior levels of competition (Till et al., 2010). A RAE trend was also identified for French male rugby union players competing in the National Rugby League; however, this trend was not statistically significant (Delorme et al., 2009). Cobley, Hanratty, O'Connor, and Cotton (2014) provide evidence of a RAE for professional Australian Rugby League players competing in the National Rugby League during the 1998 through 2010 seasons, with significantly more of these players being relatively older. For academy players from a professional rugby union club, a RAE was seen at the selection stage. However, of those athletes who ascended to the professional level, more were relatively younger (i.e., born in Q3 and Q4; McCarthy & Collins, 2014). Conversely, when examining Japanese male athletes competing in the top Japanese rugby league, there were no significant differences in the birthdate distribution of these athletes (Nakata & Sakamoto, 2011).

At the youth level, RAEs were seen in the U-13, U-14, U-15, and U-16 age groups for the representative youth rugby teams in North West England, with the largest effect noted in the U-16 group (Roberts & Fairclough, 2012). Moreover, Wilson (1999) and Cobley, Abraham, and Baker (2008) found an overrepresentation of relatively older athletes in each of their samples of school rugby players in England.

Soccer

Soccer is one of the most popular sports among researchers to study RAEs (Cobley et al., 2009b) due in large part to its cultural popularity, which has been said to enhance the chances of finding an effect (Dixon et al., 2011). Barnsley, Thompson, and Legault (1992) provide early evidence of RAEs in the 1990 World Cup, as well as the 1989 U-17 and U-20 World Tournaments, with the strongest effect occurring in the U-17 and U-20 tournaments. When considering professional players, RAEs have been found to exist in Australia (Musch & Hay, 1999), Belgium (Helsen et al., 1998), Brazil (Musch & Hay, 1999), German Bundesliga (i.e., Division I; Cobley, Schorer, & Baker, 2008; Musch & Hay, 1999; Ostapczuk & Musch, 2013), Italy and France (Salinero, Pérez, Burillo, & Lesma, 2013), Japan (Musch & Hay, 1999; Nakata & Sakamoto, 2011), Norway (Wiium, Lie, Ommundsen, & Enksen, 2010), the Netherlands and England (Dudink, 1994), and Spain (Salinero et al., 2013; Salinero, Pérez, Burillo, Lesma, & Herrero, 2014). Additionally, RAEs have been established among Belgian semi-professional and amateur senior soccer players (Vaeyens, Philippaerts, & Malina, 2005). Despite the great deal of research that has focused on the RAE, Helsen et al. (2012) analyzed professional soccer players from ten European countries over a ten-year period and concluded that the pervasiveness of the RAE had not changed over this time frame.

Williams (2010) analyzed male athletes in six Fédération Internationale de Football Association (FIFA) U-17 World Cup competitions and found that, for the entire cohort, 40% of these players were born in the first quartile of the year and only 16% in the last. Similarly, after analyzing the 2008 and 2010 women's U-17 FIFA World Cup, typical RAEs were noted for Ireland (n = 21) and Trinidad and Tobago (n =21), while inverse RAEs were shown for Ghana (n = 42) and Nigeria (n = 42; Romann & Fuchslocher, 2013a). Despite the small samples, the results displayed large effect sizes ranging from 0.3-0.4 for each team.

Youth soccer has become well-studied among researchers interested in exploring the extent to which the RAE may influence sport participation. While there may be slight differences between studies, in general, the RAE trend in soccer is consistent across multiple youth leagues. For example, RAEs have been noted within soccer in a variety of age divisions, competitive levels and countries, including: Belgium (Helsen et al., 1998; Helsen, Starkes, & Van Winckel, 2000); Brazil (Massa et al., 2014); England, (Cobley, Abraham, et al., 2008; Simmons & Paull, 2001); France (Delorme et al., 2010a); Germany (Augste & Lames, 2011); Switzerland (Romann & Fuchslocher, 2011; Romann & Fuchslocher, 2013b), and; the United States, (Baker, Schorer, Cobley, Bräutigam, et al., 2009; Glamser & Vincent, 2004; Vincent & Glamser, 2006).

While the vast majority of literature supports the presence of RAEs in soccer, a small body of literature supports the opposite. Specifically, no RAE was found for: French professional male and female soccer players (Delorme et al., 2009), Israeli-born male (Lidor et al., 2010) and female (Lidor et al., 2014) Division I soccer players, or the top Japanese female soccer players (Nakata & Sakamoto, 2012). In summary, RAEs have been established to exist in soccer across various age groups, competitive levels, and countries (Helsen, Van Winckel, & Williams, 2005).

Swimming

Swimming represents a unique domain to explore RAEs because of its individualized nature. Early research indicated a biased birth distribution among elite swimmers favouring the early part of the selection year (Baxter-Jones & Helms, 1994; Baxter-Jones, Helms, Baines-Preece, & Preece, 1994). Costa, Marques, Louro, Ferreira, and Marinho (2013) examined elite youth swimmers (ages 12 to 18 years old) and found traditional RAEs for a variety of age groups for both males and females.

Track and Field

Overall, there has been limited research conducted on athletes participating in track and field events. Considering long distance relay races (i.e., Japanese Ekiden), Nakata and Sakamoto (2011) found RAEs in top male athletes, but not among top females (Nakata & Sakamoto, 2012). Romann and Cobley (2015) examined 7,761 male Swiss 60 metre sprinters aged 8-15 and found RAEs present in all age groups, except the 13 year olds. The relative age effect was strengthened when isolating for the top 50%, 25%, and 10% sprint performances. More studies are needed to determine the potential role relative age may play in other track and field events as well as in other age groups.

Volleyball

Volleyball was one of the first sports examined for RAEs. Grondin et al. (1984) reported a nearly equal birth distribution of Canadian male and female volleyball players competing at a provincial and recreational level. Since this initial study, no RAEs have been found among French male National Volleyball League players (Delorme et al., 2009), among Israeli-born male (Lidor et al., 2010) and female Division I volleyball players (Lidor et al., 2014), or top Japanese male volleyball players (Nakata & Sakamoto, 2012). However, other researchers have found RAEs to be present among Brazilian youth volleyball players with approximately 74% of athletes born in the first half of the year (Okazaki, Keller, Fontana, & Gallagher, 2011). Furthermore, RAEs were noted among Japanese professional male (Nakata & Sakamoto, 2011) and top Japanese female volleyball players (Nakata & Sakamoto, 2012). While volleyball was one of the initial sports studied for potential birthdate advantages, few investigations have since explored this sport.

Wrestling

To the best of my knowledge no study has examined the influence of relative age on participation within in the sport of wresting.

Intercollegiate/Interuniversity Sport[6]

Noticeably lacking from the RAE literature is research pertaining to intercollegiate sport. Currently, there are only a few published studies that have explored the RAE within this setting (e.g., Chittle, Horton, & Dixon, 2016; Dixon et al., 2013; Glamser & Marciani, 1992; Grondin et al., 1984; Montelpare et al., 2000). Moreover, this area continues to receive scant attention, particularly in CIS. Researchers have demonstrated RAEs among CIAU ice hockey players (Montelpare et al., 2000) and NCAA Division I female softball players (Dixon et al., 2013). However, others have found RAEs to be absent in overall samples of Canadian university ice hockey players (Grondin et al., 1984), two NCAA Division I football teams (Glamser & Marciani, 1992), and NCAA Division I basketball players (Chittle et al., 2016). Of the few studies that have examined intercollegiate sport, only some have taken into consideration the notion of academic timing (AT).

Academic Timing

[6] Intercollegiate sport is a term often used to describe varsity sport that occurs in a university or college in the United States. Interuniversity sport is a term used in Canada that refers to varsity sport occurring in a university setting.

A unique, yet complicating, factor when examining RAEs within interuniversity and/or intercollegiate sport is that athletes can differ greatly in their ages. The term academic timing (AT) was coined by Glamser and Marciani (1992) more than two decades ago when they noticed that athletes participating in school sports often differ in ages because they are grouped based on grade level rather than age. The term AT can explain how differences in a student-athlete's actual and expected athletic eligibilities within an academic setting may influence his or her participation and/or success in interuniversity and/or intercollegiate sport (Dixon et al., 2013). For example, a student-athlete born in 1998 who begins kindergarten at five years of age ought to begin his or her first year of university and be in his or her first year of athletic eligibility in the fall of 2016, assuming this individual did not fail or skip one or more grades prior to commencing university. Correspondingly, those born in 1997, 1996, 1995, 1994 would be in their second, third, fourth, and fifth years of eligibility, respectively. When examining AT, student-athletes are considered to be 'on-time' when their current year of athletic eligibility coincides with their expected year of athletic eligibility, based on their year of birth. Conversely, student-athletes are considered to be 'delayed' when their current athletic eligibility year corresponds with a younger cohort of student-athletes. For example, a student-athlete born in 1998 in his or her first year of athletic eligibility in the fall of 2016 would be classified as on-time. Alternatively, a student-athlete born in 1997 and in his or her first year of athletic eligibility in the fall of 2016 would be considered delayed.

Glamser and Marciani (1992) first realized the importance of AT when they examined the birthdates of student-athletes listed within intercollegiate baseball and football media guides from two NCAA Division I state universities. Prior to accounting for AT, these authors found no evidence of a RAE within their sample of football players. However, once these researchers isolated their analyses to student-athletes who were on-time, they noticed that football players were five times more likely to be born in Q1 than Q4. Moreover, they noted that 45% of the football players were delayed by at least one year. With respect to the baseball data, the birthdate distribution of players did not indicate a relative age advantage. However, when considering AT, as many as 37% of these players were found to be delayed.

Subsequent research by Dixon et al. (2013) witnessed similar trends regarding AT among NCAA Division I female softball players. When considering their overall sample of student-athletes they noted a significant over-representation of student-athletes born in Q1 (28.14%) and a significant under-representation of athletes born in Q3 (21.59%). After taking into consideration the notion of AT, they revealed a stronger RAE among on-time students, with 36.05% of these athletes born in Q1 and 7.89% born in Q4. In contrast, when looking at those who were delayed, they found a significant reversal in the traditional RAE, whereby 11.89% of these athletes were born in Q1 and 54.05% born in Q4.

Chittle et al. (2016) evaluated NCAA Division I men's and women's basketball players and found similar results to Dixon et al. (2013) and Glamser and Marciani (1992). When examining their overall samples of student-athletes, they found no RAE for female or male basketball players. However, after isolating for those players who were on-time, they found a significant traditional RAE, with male and female athletes approximately 30 and slightly over five times more likely to be born in Q1 than Q4, respectively.

Conversely, delayed males and females were nearly twice and almost five times more likely to be born in Q4 than Q1, respectively.

Overall, AT is an important factor that can influence the RAE in interuniversity and/or intercollegiate sports. Based on the results of these previous studies, it appears that delaying one's athletic eligibility by one or more years may be a method to help equalize playing opportunities for those who are relatively younger. This is a possibility because Glamser and Marciani (1992) and Chittle et al. (2016) witnessed no RAEs in their entire samples of student-athletes, indicating those who are relatively younger are not being disadvantaged, so long as they delay their eligibilities by one or more years.

Academic timing is an environmental constraint that is associated with educational systems, specifically intercollegiate/interuniversity sport. For example, Wattie et al. (2015) highlighted that "…environmental constraints refer to the broader social constructs that affect development, including physical environment, socio-cultural environment, policies, and the influence of important actors in athletes' lives, such as coaches, family and friends" (p. 84). The structure of intercollegiate/interuniversity sport allows for student-athletes to differ quite considerable in ages. This is, in part, due to the policies and regulations imposed by CIS that allow students to redshirt and/or delay entry into university for various reasons and still compete. Consequently, it is this unique environment that affords student-athletes the opportunity to be on-time and/or delayed.

While there are many reasons for student-athletes to be delayed in terms of their athletic eligibility, it is difficult to determine precisely why without a detailed account of their life and educational histories. In some cases, student-athletes can become delayed through their participation in athletics. A common cause of this is ‘redshirting,’ which allows a student-athlete to be a member of a varsity team but not compete in league play and, therefore, not use up a year of athletic eligibility. Other causes of delay may include failing or repeating one or more grades, or commencing kindergarten late. Repeating a year in school may be a probable reason for delay considering that research has suggested that RAEs may influence who is retained for an additional year in the same grade (e.g., Elder & Lubotsky, 2009). Furthermore, Deming and Dynarski (2008) have found strong evidence of parents intentionally holding back their children from beginning kindergarten on time (i.e., ‘academic redshirting’). Similarly, *60 Minutes* has reported on this phenomenon occurring as a way for parents to try and ensure that their children gain the athletic and/or academic advantages that normally accrue to those who are relatively older (CBS Interactive, 2012). Alternatively, some student-athletes may be delayed after taking a voluntary fifth year of year of high school, which is often referred to as a ‘victory lap.’ Students will sometimes choose this route in order to continue their participation in extracurricular activities (i.e., sports), improve their academics, or because of a perceived lack of maturity to attend university (Brady & Allingham, 2010).

It is possible that the disparity in RAE investigations at this level is due to maturational differences evening out. Specifically, the mechanisms of physical development, psychological factors, and relative experience (Musch & Grondin, 2010) may be minimized by the time athletes reach intercollegiate/interuniversity sport. For example, Cobley et al. (2009b) found age to be a moderator of the RAE, whereby the RAE risk increased from childhood to adolescence, peaking from 15-18 years of age, before declining at the senior age category (19 years and older). Given that student-athletes often begin university around 18 years of age, it is possible that few studies have examined this population due to the expectation that relative age would no longer be a strong developmental and/or selection influence in intercollegiate sport. However, this assumption fails to take into consideration the accumulated selection advantages often awarded to those who are relatively older (i.e., more practice/play opportunities, access to better coaches), which may have led to these individuals continuing their participation in sport and, ultimately, becoming better athletes.

Moreover, it is possible that this competitive level has been overlooked due to the initial appearance of an equal birthdate distribution among athletes (i.e., null results) and researchers failing to account for the academic timing of student-athletes, which has been found to moderate the birth distribution of these individuals (e.g., Chittle et al., 2016; Dixon et al., 2013). Ignoring academic timing in an intercollegiate/interuniversity setting can lead to researchers overlooking the true moderating influence relative age has on CIS participation.

Proposed Solutions to the RAE

To date, numerous solutions to the RAE have been proposed by researchers. However, as of yet, they have not been attractive enough to sport administrators to outright change or adapt their current age-grouping policies. Without a change in the current state of sport development programs, it is possible that promising athletes will continue to be overlooked early in their sporting careers as a result of being relatively younger (Baker et al., 2010; Musch & Grondin, 2001). Early suggestions to minimize RAEs included changing annual age-groupings by either modifying the annual cut-off date, rotating the cut-off date each year (Barnsley et al., 1985), or by altering age-grouping bandwidths (Baker et al., 2010). The downfall to such solutions is there would still be RAEs present; all that would change under these circumstances is who gets advantaged or disadvantaged based upon who is relatively older or younger using the newly established cut-off date (Baker et al., 2010; Cobley et al., 2009b). Likewise, Boucher and Halliwell (1991) suggested using a 'Novem System' whereby nine-month bandwidths are used to help ensure the same participants are not continuously disadvantaged each year. Furthermore, the Relative Age Fair (RAF) Cycle System was suggested to help overcome RAEs within Canadian junior ice hockey (Hurley, Lior, & Traczie, 2001). This system involved altering annual cut-off dates by three months each year to allow athletes to experience being in each quartile (i.e., Q1, Q2, Q3, Q4) within a four year time period. While these proposed solutions may help to minimize RAEs, they are administratively challenging for sport organizations to implement (Baker et al., 2010; Cobley et al., 2009b; Musch & Grondin, 2001).

Other potential solutions include grouping athletes based on their biological ages and/or anthropometric measurements (e.g., height and weight) to help ensure developmental similarities among competitors (Barnsley & Thompson, 1988; Musch & Grondin, 2001). This type of grouping system is commonly used in wrestling and boxing. Similarly, Pop Warner Football in the United States utilizes a similar grouping policy where young football players are categorized based on a combination of their age and weight (Pop Warner Little Scholars Incorporated, n.d.). Another solution to help overcome potential size and/or weight advantages among athletes is to implement a quota system to ensure there are an equal number of relatively older and younger athletes on a team (Barnsley & Thompson, 1988). Alternatively, Helsen et al. (1998) proposed regulating the average age of a team, while Baker et al. (2010) suggested that policies could be introduced to help ensure an equal distribution of playing time across athletes of different relative ages. These methods would help to ensure coaches do not just select and play individuals born in the early months of the year, thereby allowing those who are relatively younger to develop their skills as well. Furthermore, these suggestions are beneficial as they help to account for individual variability in terms of physical characteristics However, they are difficult to implement without support from sport governing bodies (Baker et al, 2010; Cobley et al., 2009b).

Romann and Cobley (2015) provided evidence in Swiss male sprinters that adjusting raw sprint times based on an individual's relative age was effective at eliminating RAEs. Specifically, these authors applied corrective adjustments to raw sprint times (i.e., sprint times were adjusted to account for an athlete's relative age) and found it to be effective, in most cases, for equalizing the distribution of birthdates for various age categories and performance levels (i.e., top 50%, 25%, and 10%). This method would help to ensure sprinters are not overlooked or potentially disadvantaged due to later growth (Romann & Cobley, 2015). While this may be an effective solution to help enhance athletes' development in individual sports such as track and field events, it is a relatively new suggestion and would need to be evaluated and tested for its applicability in other sport contexts.

More simple solutions to the RAE include delaying the process of selection and representation (i.e., streaming) of athletes until after puberty (Baker et al, 2010; Cobley et al., 2009b), or simply raising awareness and warning practitioners of the negative consequences associated with RAEs (Baker et al, 2010; Cobley et al., 2009b; Musch & Grondin, 2001). Encouraging coaches to select athletes based on technical skill rather than physical size, and to de-emphasize competition, may help to maintain the interest, motivation, and participation of young athletes (Musch & Grondin, 2001). Furthermore, coaches should be advised to consider perceptual, cognitive, and motor skills when selecting athletes to help reduce the likelihood of selecting athletes based on physical size and strength (Baker et al, 2010; Cobley et al., 2009b).

References

Addona, V., & Yates, P. A. (2010). A closer look at the relative age effect in the National Hockey League. *Journal of Quantitative Analysis in Sports, 6*(4), 1-17. doi:10.2202/1559-0410.1227

Armstrong, H. G. (1966). A comparison of the performance of summer and autumn-born children at eleven and sixteen. *British Journal of Educational Psychology, 36*(1), 72-76. doi: 10.1111/j.2044-8279.1966.tb01841.x

Augste, C., & Lames, M. (2011). The relative age effect and success in German elite U-17 soccer teams. *Journal of Sports Sciences, 29*(9), 983-987. doi: 10.1080/02640414.2011.574719

Baker, J., & Horton, S. (2004). A review of primary and secondary influences on sport expertise. *High Ability Studies*, *15*(2), 211-228. doi: 10.1080/1359813042000314781

Baker, J., & Logan, A. J. (2007). Developmental contexts and sporting success: Birth date and birthplace effects in National Hockey League draftees 2000–2005. *British Journal of Sports Medicine*, *41*(8), 515–517. doi:10.1136/bjsm.2006.033977

Baker, J., Schorer, J., & Cobley, S. (2010). Relative age effects: An inevitable consequence of elite sport? *Sportwissenschaft, 40*(1), 26-30. doi: 10.1007/s12662-009-0095-2

Baker, J., Schorer, J., Cobley, S., Bräutigam, H., & Büsch, D. (2009). Gender, depth of competition and relative age effects in team sports. *Asian Journal of Exercise & Sports Science*, *6*(1), 1-7.

Baker, J., Schorer, J., Cobley, S., Schimmer, G., & Wattie, N. (2009). Circumstantial development and athletic excellence: The role of date of birth and birthplace. *European Journal of Sport Science*, *9*(6), 329-339. doi: 10.1080/17461390902933812

Barnsley, R. H., & Thompson, A. H. (1988). Birthdate and success in minor hockey: The key to the NHL. *Canadian Journal of Behavioural Science, 20*(2), 167-176. http://dx.doi.org/10.1037/h0079927

Barnsley, R. H., Thompson, A. H., & Barnsley, P. E. (1985). Hockey success and birthdate: The RAE. *Canadian Association for Health, Physical Education, and Recreation, 51*, 23-28.

Barnsley, R. H., Thompson, A. H., & Legault, P. (1992). Family planning: Football style. The relative age effect in football. *International Review for the Sociology of Sport*, *27*(1), 77-86. doi: 10.1177/101269029202700105

Barrow, H. M., & McGee, R. (1971). *A practical approach to measurement in physical education*. Philadelphia, PA: Lea & Febiger.

Baxter-Jones, A. & Helms, P. (1994). Born too late to win? *Nature, 370*(6486), 186. doi:10.1038/370186b0

Baxter-Jones, A., Helms, P., Baines-Preece, J., & Preece, M. (1994). Growth and development of male athletes: Implications for identification of talent. *Journal of Sport Sciences, 12*, 156.

Bedard, K., & Dhuey, E. (2006). The persistence of early childhood maturity: International evidence of long-run age effects. *The Quarterly Journal of Economics*, *121*(4), 1437-1474.

Boucher, J., & Halliwell, W. (1991). The novem system: A practical solution to age grouping. *Canadian Association for Health, Physical Education, and Recreation*, *57*, 16-20.

Boucher, J. L., & Mutimer, B. T. (1994). The relative age phenomenon in sport: A replication and extensions with ice-hockey players. *Research Quarterly for Exercise and Sport, 65*(4) 377-81. doi: 10.1080/02701367.1994.10607644

Brady, P., & Allingham, P. (2010). Pathways to university: The "victory lap" phenomenon in Ontario. *Canadian Journal of Educational Administration and Policy, 113*, 1-25.

Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *American Psychologist*, *32*, 513-531.

Bruner, M. W., Macdonald, D. J., Pickett, W., & Côté, J. (2011). Examination of birthplace and birthdate in world junior ice hockey players. *Journal of Sports Sciences*, *29*(12), 1337–1344. doi: 10.1080/02640414.2011.597419

Canadian Interuniversity Sport. (n.d.). *Athlete's guide*. Retrieved from http://english.cis-sic.ca/information/members_info/pdfs/pdf_elig_pack/13-14/athletes_guide.pdf

CBS Interactive (2012). Redshirting: Holding kids back from kindergarten. *60 Minutes*. Retrieved from http://www.cbsnews.com/8301-18560_162-57390128/redshirting-holding-kids-back-from kindergarten/?pageNum=5&tag=contentMain;contentBody

Chittle, L., Horton, S., & Dixon, J. C. (2016). Time out or fast break? Relative age effect in NCAA Division I basketball. *Journal of Sport Behavior*, *39*(2), 107-125.

Chittle, L., Horton, S., Weir, P., & Dixon, J. C. (2015). Investigating the relationship between the relative age effect and leadership behaviors among male ice hockey players. *International Review for the Sociology of Sport,* 1-18. doi: 10.1177/1012690215616271

Cobley, S., Abraham, C., & Baker, J. (2008). Relative age effects on physical education attainment and school sport representation. *Physical Education and Sport Pedagogy, 13*(3), 267-276. doi: 10.1080/17408980701711983

Cobley, S., Baker, J., Wattie, N., & McKenna, J. M. (2009a). How pervasive are relative age effects in secondary school education? *Journal of Educational Psychology, 101*(2), 520- 528. http://dx.doi.org/10.1037/a0013845

Cobley, S., Baker, J., Wattie, N., & McKenna, J. M. (2009b). Annual age-grouping and athlete development: A meta-analytic review of relative age effects in sport. *Sports Medicine, 39*(3), 235-256.

Cobley, S., Hanratty, M., O'Connor, D., & Cotton, W. (2014). First club location and relative age influences on being a professional Australian Rugby League Player. *International Journal of Sports Science & Coaching, 9*(2), 335-346. doi: 10.1260/1747-9541.9.2.335

Cobley, S. P., Schorer, J., & Baker, J. (2008). Relative age effects in professional German soccer: A historical analysis. *Journal of Sports Sciences*, *26*(14), 1531-1538. doi: 10.1080/02640410802298250

Costa, A. M., Marques, M. C., Louro, H., Ferreira, S. S., & Marinho, D. A. (2013). The relative age effect among elite youth competitive swimmers. *European Journal of Sport Science, 13*(5), 437-444. doi: 10.1080/17461391.2012.742571

Côté, J., MacDonald, D. J., Baker, J., & Abernethy, B. (2006). When 'where' is more important than 'when': Birthplace and birthdate effects on the achievement of sporting expertise. *Journal of Sports Sciences, 24*(10), 1065-1073. doi: 10.1080/02640410500432490

Daniel, T. E., & Janssen, C. T. L., (1987). More on the relative age effect. *CAHPER-ACSEPL Journal, 53*(2), 21-24.

Delorme, N., Boiché, J., & Raspaud, M. (2009). The relative age effect in elite sport: The French case. *Research Quarterly for Exercise and Sport, 80*(2), 336–344. doi: 10.1080/02701367.2009.10599568

Delorme, N., Boiché, J., & Raspaud, M. (2010a). Relative age effect in female sport: A diachronic examination of soccer players. *Scandinavian Journal of Medicine & Science in Sports, 20*, 509-515. doi: 10.1111/j.1600-0838.2009.00979.x

Delorme, N., Boiché, J., & Raspaud, M. (2010b). Relative age and dropout in French male soccer. *Journal of Sports Sciences*, *28*(7), 717-722. doi: 10.1080/02640411003663276

Delorme, N., Chalabaev, A., & Raspaud, M. (2011). Relative age is associated with sport dropout: Evidence from youth categories of French basketball. *Scandinavian Journal of Medicine & Science in Sports, 21*, 120-128. doi: 10.1111/j.1600-0838.2009.01060.x

Delorme, N., & Raspaud, M. (2009). The relative age effect in young French basketball players: A study on the whole population. *Scandinavian Journal of Medicine & Science in Sports, 19*(2), 235–242. doi: 10.1111/j.1600-0838.2008.00781.x

Deming, J. D., & Dynarski, S. (2008). The lengthening of childhood. *Journal of Economic Perspectives*, *22*(3), 71–92.

Dhuey, E., & Lipscomb, S. (2008). What makes a leader? Relative age and high school leadership. *Economics of Education Review, 27*, 173-183.

Dixon, J. C., Horton, S., & Weir, P. (2011). Relative age effects: Implications for leadership development. *International Journal of Sport and Society, 2*(2), 1-15.

Dixon, J. C., Liburdi, V., Horton, S, & Weir, P. (2013). An examination of the impact of relative age effects and academic timing on intercollegiate athletics participation in women's softball. *Journal of Intercollegiate Sports, 6*, 147-163.

Dudink, A. D. (1994). Birth date and sporting success. *Nature, 368*(6472)*,* 592. doi:10.1038/368592a0

Elder, T. (2010). The importance of relative standards in ADHD diagnoses: Evidence based on exact birth dates. *Journal of Health Economics, 29*(5)*,* 641-656. doi:10.1016/j.jhealeco.2010.06.003

Elder, T. E., & Lubotsky, D. H. (2009). Kindergarten entrance age and children's achievement: Impacts of state policies, family background, and peers. *Journal of Human Resources, 44*(3), 641-683. doi: 10.3368/jhr.44.3.641

Esteva, S., & Drobnic, F. (2006). Birthdate and basketball success. *FIBA Assist Magazine*, *18*, 64-66.

Evans, W. N., Morrill, M. S., & Parente, S. T. (2010). Measuring inappropriate medical diagnosis and treatment in survey data. The case of ADHD among school-age children. *Journal of Health Economics, 29*(5), 657-673. doi: 10.1016/j.jhealeco.2010.07.005

Freyman, R. (1965). Further evidence on the effect of date of birth on subsequent school performance. *Educational Research, 8*, 58-64. doi:10.1080/0013188650080105

García, M. S., Aguilar, O. G., Romero, J. J. F., Lastra, D. F., & Oliveira, G. E. (2014). Relative age effect in lower categories of international basketball. *International Review for the Sociology of Sport, 49*(5), 526-535. doi:10.1177/1012690212462832

Gibbs, B. G., Jarvis, J. A., & Durfur, M. J. (2011). The rise of the underdog? The relative age effect reversal among Canadian-born NHL hockey players: A reply to Nolan and Howell. *International Review for the Sociology of Sport, 47*(5), 644-649.

Glamser, F. D., & Marciani, L. M. (1992). The birthdate effect and college athletic participation: Some comparisons. *Journal of Sport Behavior, 15*(3), 227-238.

Glamser, F. D., & Vincent, J. (2004). The relative age effect among elite American youth soccer players. *Journal of Sport Behavior*, *27*(1), 31-38.

Grondin, S., Deschaies, P., & Nault, L. P. (1984). Trimestres de naissance et participation au hockey et au volleyball. *La Revue Québecoise de l'Activité Physique, 2*, 97-103.

Hancock, D. J., Adler, A. L., & Côté, J. (2013) A proposed theoretical model to explain relative age effects in sport. *European Journal of Sport Science*, *13*(6), 630-637. doi: 10.1080/17461391.2013.775352

Hancock, D. J., Seal, K., Young, B. W., Weir, P. L., & Ste-Marie, D. M. (2013). Examining mechanisms that contribute to relative age effects in pre-pubescent female ice hockey players. *Talent Development & Excellence, 5*(2), 59-66.

Hancock, D. J., Ste-Marie, D. M., & Young, B. W. (2013). Coach selections and the relative age effect in male youth ice hockey. *Research Quarterly for Exercise and Sport. 84*(1), 126-130. doi: 10.1080/02701367.2013.762325

Helsen, W. F., Baker, J., Michiels, S., Schorer, J., Van Winckel, J., & Williams, A. M. (2012). The relative age effect in European professional soccer: Did ten years of research make any difference? *Journal of Sports Sciences*, *30*(15), 1665-1671. doi: 10.1080/02640414.2012.721929

Helsen, W. F., Starkes, J. L., & Van Winckel, J. (1998). The influence of relative age on success and dropout in male soccer players. *American Journal of Human Biology, 10,* 791-798.

Helsen, W. F., Starkes, J. L., & Van Winckel, J. (2000). Effect of change in selection year on success in male soccer players. *American Journal of Human Biology, 12*(6)*,* 729-735.

Helsen, W. F., Van Winckel, J., & Williams, M. (2005). The relative age effect in youth soccer across Europe. *Journal of Sports Sciences, 23*(6), 629-636. doi: 10.1080/02640410400021310

Hockey Canada. (2013). *Articles by-laws regulations history*. Retrieved from http://assets.ngin.com/attachments/document/0044/0627/2013_14_articles_bylaws_e.pdf

Hurley, W., Lior, D., & Tracze, S. (2001). A proposal to reduce the age discrimination in Canadian minor hockey. *Canadian Public Policy, 27*(1), 65-75. doi: 10.2307/3552374

Lemez, S., Baker, J., Horton, S., Wattie, N., & Weir, P. (2014). Examining the relationship between relative age, competition level, and dropout rates in male youth ice-hockey players. *Scandinavian Journal of Medicine & Science in Sports, 24*(6)*,* 935-942. doi:10.1111/sms.12127

Lidor, R., Arnon, M., Maaya, Z., Gershon, & Côté, J. (2014). Relative age effect and birthplace effect in Division I female ballgame players- the relevance of sport-specific factors. *International Journal of Sport and Exercise Psychology, 12*(1), 19-33.

Lidor, R., Côté, J., Arnon, M., Zeev, A., & Cohen-Maoz, S. (2010). Relative age and birthplace effects in Division I players-Do they exist in a small country. *Talent Development & Excellence, 2*(2), 181-192.

MacDonald, D. J., Cheung, M., Côté, J., & Abernethy, B. (2009). Place but not date of birth influences the development and emergence of athletic talent in American football. *Journal of Applied Sport Psychology, 21*(1)*,* 80-90. doi: 10.1080/10413200802541868

Massa, M., Caldas Costa, E., Moreira, A., Thiengo, C. R., Rodrigues de Lima, M., Quispe Marquez, W., & Saldanha Aoki, M. (2014). The relative age effect in soccer: A case study of the São Paulo Football Club. *Brazilian Journal of Kineanthropometry & Human Performance*, *16*(4), 399-405.

McCarthy, N., & Collins, D. (2014). Initial identification and selection bias versus the eventual confirmation or talent: Evidence for the benefits of a rocky road? *Journal of Sports Sciences, 32*(17). 1604-1610. doi: 10.1080/02640414.2014.908322

Montelpare, W. J., Scott, D., & Pelino, M. (2000). Tracking the relative age effect across minor, amateur and professional ice-hockey leagues. In A. B. Ashare (Ed.), *Safety in ice hockey* (Vol. 3, pp. 250-260). Philadelphia, PA: American Society for Testing and Materials.

Musch, J., & Grondin, S. (2001). Unequal competition as an impediment to personal development: A review of the relative age effect in sport. *Developmental Review, 21*, 147-167.

Musch, J., & Hay, R. (1999). The relative age effect in soccer: Cross-cultural evidence for a systematic discrimination against children born late in the competition year. *Sociology of Sport Journal, 16*, 54-64.

Nakata, H., & Sakamoto, K. (2011). Relative age effect in Japanese male athletes. *Perceptual and Motor Skills, 113*(2), 570-574. doi: 10.2466/05.10.11.PMS.113.5.570-574

Nakata, H., & Sakamoto, K. (2012). Sex differences in relative age effects among Japanese athletes. *Perceptual and Motor Skills, 115*(1), 179-186. doi: 10.2466/10.05.17.PMS.115.4.179-186

Newell, K. M. (1986). Constraints on the development of coordination. In M. G. Wade, H. T. A. Whiting (Eds.), *Motor development in children: Aspects of coordination and control* (pp. 341-361). Dordrecht, Netherlands: Martinus Nijhoff.

Nolan, J. E., & Howell, G. (2010). Hockey success and birth date: The relative age effect revisited. *International Review for the Sociology of Sport, 45*(4), 507-512. doi: 10.1177/1012690210371560

Okazaki, F. A., Keller, B., Fontana, F. E., & Gallagher, J. D. (2011). The relative age effect among female Brazilian youth volleyball players. *Research Quarterly for Exercise & Sport, 82*(1), 135-139. doi: 10.1080/02701367.2011.10599730

Ostapczuk, M., & Musch, J. (2013). The influence of relative age on the composition of professional soccer squads. *European Journal of Sport Science, 13*(3), 249-255. doi: 10.1080/17461391.2011.606841

Pop Warner Little Scholars Incorporated. (n.d.). *Age and weights*. Retrieved from: http://www.popwarner.com/football/footballstructure.htm

Raschner, C., Müller, L., & Hildebrandt, C. (2012). The role of a relative age effect in the first Youth Olympic Games in 2012. *British Journal of Sports Medicine, 46,* 1038-1043. doi:10.1136/bjsports-2012-091535

Roberts, S. J., & Fairclough, S. J. (2012). The influence of relative age effects in representative youth rugby union in the north west of England. *Asian Journal of Exercise & Sport Science, 9*(2), 86-98.

Romann, M., & Cobley, S. (2015). Relative age effects in athletic sprinting and corrective adjustments as a solution for their removal. *PLoS One, 10*(4), e0122988. doi: 10.1371/journal.pone.0122988

Romann, M., & Fuchslocher, J. (2011). Influence of the selection level, age and playing position on relative age effects in Swiss women's soccer. *Talent Development & Excellence*, *3*(2), 239-247.

Romann, M., & Fuchslocher, J. (2013a). Influences of player nationality, playing position, and height on relative age effects at women's under-17 FIFA World

Cup. *Journal of Sports Sciences*, *31*(1), 32-40. doi: 0.1080/02640414.2012.718442

Romann, M., & Fuchslocher, J. (2013b). Relative age effects in Swiss junior soccer and their relationship with playing position. *European Journal of Sport Science*, *13*(4), 356-363. doi: 10.1080/17461391.2011.635699

Salinero, J. J., Pérez, B., Burillo, P., & Lesma, M. L. (2013). Relative age effect in European professional football. Analysis by position. *Journal of Human Sport & Exercise*, *8*(4), 966-973. doi: 10.4100/jhse.2013.84.07

Salinero, J. J., Pérez, B., Burillo, P., Lesma, M., & Herrero, M. (2014). The relative age effect in Spanish professional football. *Revista Internacional De Medicina Y Ciencias De La Actividad Física Y El Deporte, 14*(56), 591-601.

Schorer, J., Cobley, S., Büsch, D., Bräutigam, H., & Baker, J. (2009). Influences of competition level, gender, player nationality, career stage and playing position on relative age effects. *Scandinavian Journal of Medicine & Science in Sports, 19*(5), 720-730.

Schorer, J., Neumann, J., Cobley, S. P., Tietjens, M., & Baker, J. (2011). Lingering effects of relative age in basketball players' post athletic careers. *International Journal of Sports Science & Coaching, 6*(1), 143-147. doi: 10.1260/1747-9541.6.1.143

Simmons, C., & Paull, G. C. (2001). Season-of-birth bias in association football. *Journal of Sports Sciences*, *19*(9), 677-686.

Smith, J. (2009). Can regression discontinuity help answer an age-old question in education? The effect of age on elementary and secondary school achievement.

The B. E. Journal of Economic Analysis & Policy, *9*(1), 1-28.

Smith, K. L., & Weir, P. L. (2013). An examination of the relative age effect in developmental girls' hockey in Ontario. *High Ability Studies, 24*(2), 171-184. doi: 10.1080/13598139.2013.847357

Stanaway, K. B., & Hines, T. M. (1995). Lack of season of birth effect among American athletes. *Perceptual and Motor Skills, 81*, 952-954. doi: 10.2466/pms.1995.81.3.952

Stenling, A., & Holmström, S. (2014). Evidence of relative age effects in Swedish women's ice hockey. *Talent Development & Excellence, 6*(1), 31-40.

Till, K., Cobley, S., Wattie, N., O'Hara, J. Cooke, C., & Chapman, C. (2010). The prevalence, influential factor and mechanisms of relative age effect in UK Rugby League. *Scandinavian Journal of Medicine & Science in Sports, 20*(2), 320-329. doi: 10.1111/j.1600-0838.2009.00884.x

Thompson, A. H., Barnsley, R. H., & Dyck, R. J. (1999). A new factor in youth suicide: The relative age effect. *Canadian Journal of Psychiatry, 44*(1), 82-85.

Turnnidge, J., Hancock, D. J., & Côté, J. (2014). The influence of birth date and place of development on youth sport participation. *Scandinavian Journal of Medicine & Science in Sports, 24*(2), 461-468. doi: 10.1111/sms.12002

Vaeyens, R., Philippaerts, R. M., & Malina, R. M. (2005). The relative age effect in soccer: A match-related perspective. *Journal of Sports Sciences, 23*(7), 747-756. doi: 10.1080/02640410400022052

Vincent, J., & Glamser, F. D. (2006). Gender differences in the relative age effect among US Olympic development program youth soccer players. *Journal of Sports Sciences*, *24*(4), 405-413. doi: 10.1080/02640410500244655

Wattie, N., Baker, J., Cobley, S., & Montelpare, W. J. (2007). A historical examination of relative age effects in Canadian hockey players. *International Journal of Sport Psychology, 38*(2), 178-186.

Wattie, N., Cobley, S., Macpherson, A., Howard, A., Montelpare, W. J., & Baker, J. (2007). Injuries in Canadian youth ice hockey: The influence of relative age. *Pediatrics, 120*(1), 142-148. doi: 10.1542/peds.2006-2672

Wattie, N., Schorer, J., & Baker, J. (2015). The relative age effect in sport: A developmental systems model. *Sports Medicine*, *45*(1), 83-94. doi: 10.1007/s40279-014-0248-9

Weir, P. L., Smith, K. L., Paterson, C., & Horton, S. (2010). Canadian women's ice hockey - evidence of a relative age effect. *Talent Development & Excellence, 2*(2), 209-217.

Wiium, N., Lie, S. A., Ommundsen, Y., & Enksen, H. R. (2010). Does relative age effect exist among Norwegian professional soccer players? *International Journal of Applied Sports Sciences*, *22*(2), 66-76.

Williams, J. H. (2010). Relative age effect in youth soccer: Analysis of the FIFA U17 World Cup competition. *Scandinavian Journal of Medicine & Science in Sports, 20*(3), 502-508. doi: 10.1111/j.1600-0838.2009.00961.x

Wilson, G. (1999). The birthdate effect in school sports teams. *European Journal of Physical Education*, *4*(2), 139-145. doi: 10.1080/174089899004020

VITA AUCTORIS

NAME:	Laura Mae Marie Chittle
PLACE OF BIRTH:	Windsor, ON
YEAR OF BIRTH:	1992
EDUCATION:	Essex District High School, Windsor, ON, 2010
	University of Windsor, B.H.K., Windsor, ON, 2014
	University of Windsor, M.H.K., Windsor, ON, 2016